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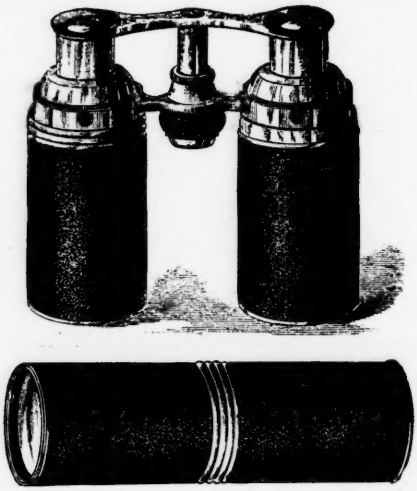

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THE MONTHLY

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JUNE, 1879.

I. COLOUR AND ITS RECOGNITION.*

IT is not without some reluctance that we venture to re-open a question which has been abundantly handled both by workers and dreamers, and which, though by no means decided or exhausted, must await further discoveries for its ultimate solution. We wish, however, to lay before our readers certain speculations calculated to prove valuable and suggestive not merely to professed men of science, but also to the cultivated lay-public. Although disclaiming all right to rank as a biological specialist, Mr. Grant Allen, the author of the work before us, has, in our opinion, thrown a welcome and seasonable light upon some of the most obscure features of the animal and vegetable world. Even though certain of the conclusions to which he has led may not be accepted as final, they must surely give a new stimulus and a fresh direction to research.

Mr. Allen's immediate object is to prove that the colour-sense—so far from being, as Dr. Magnus and Mr. Gladstone have on mere philological grounds sought to demonstrate, a recent development of the human mind—must have existed in pre-historical ages, and that it may be traced far down the animal series. In opposition, again, to a far more formidable authority, Mr. A. R. Wallace, he defends the theory of Sexual Selection. In the very outset of his work he suggests the law that "only those animals display beautiful colours, due to Sexual Selection, in whom a taste for colour has already been aroused by the influence of flowers, fruits, or brilliant insects, their habitual food,"—a principle which we shall have to examine in some detail. He shows

* The Colour-Sense, its Origin and Development: an Essay in Comparative Psychology. By GRANT ALLEN, B.A. London: Trübner and Co.

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that, practically speaking, our idea of colour corresponds with that of the lower animals. He traces a connection between sight and the power of locomotion, contending that this sense is most developed among winged creatures.

We find it, then, asserted, that a perception and taste for colour is first aroused in animals by the influence of the objects on which they feed. On the other hand, the disciples of the new school of Natural History—and no one more emphatically than our author—contend that it is to the colour-sense, especially of insects and birds, that we owe all the varied colouration of blossoms and fruits as distinct from the monotonous green of earlier geological epochs. We can admit that, in virtue of the principle of Natural Selection, the smallest step on the part of a plant to produce a gay efflorescence, or the smallest step on the part of an insect towards the appreciation of a source of edible pollen or saccharine matter, would, *pro tanto*, give the advantage in the struggle for existence to the species in which it might occur. But where and how was the first step taken? "Did flowers show an original tendency to the production of coloured adjuncts prior to the selective action of insects? Did insects possess any tendency vaguely to discriminate colours apart from the reactive influence of entomophilous flowers?" Mr. Allen, in addressing himself to these questions, argues that the normal green colour of plants is connected with de-oxidation, and the consequent storing up of energy. But where oxidation and the expenditure of energy are known to be in progress,—as in decaying leaves, in buds, young shoots, and sprouts, especially those put forth in the dark, where the reductive action of the solar rays is of course wanting,—we find a rich and varied display of colour. The author gives as instances the sprouts of peonies, which are of a full dark red: the rosy stems and yellow early leaves of rhubarb, &c. Now all these colours are indeed merely adventitious. But in flowers, where the colouration is a "purposive adaptation," we find, even in anemophilous species, a rise of temperature, from which we know that oxidation is in progress. Hence we may naturally expect that all floral organs, whether anemophilous or entomophilous, would have a tendency to the production of bright colours. This is accordingly seen even in the mosses, lycopods, and ferns. We have thus a groundwork of differentiated colouring upon which Natural Selection or any other agency may operate. The author accordingly decides that "the bright pigments of entomophilous plants are due

originally to natural oxidation aided by the selective action of insects." To the second question, whether insects had any tendency to discriminate colours apart from the reaction of entomophilous flowers, he replies that colours differ not merely qualitatively, but quantitatively, according as they absorb a greater or less proportion of the luminous rays. Thus "white might be distinguished by the primitive eye from green, brown, or black." If a beginning is thus given the rest will easily follow.

In a chapter devoted to the colour-sense of insects, the reality of which he proves by an appeal to numerous and fully-established facts, the author reverts to the views of Mr. Gladstone, Dr. Geiger, and Dr. Magnus, and declares that they have been "partially adopted" even by Mr. Wallace in his "Tropical Nature." This we can scarcely admit, since in that very work he points out the cardinal error in Mr. Gladstone's reasoning, viz., that the absence of a precise nomenclature for colours is no proof of the lack of colour-perception. In disposing of the old theory of the colouration of flowers, our author happily remarks:—"Not even the watch-maker deity of Paley himself, one may suppose, would have invented flowers in the Secondary Age for the sole gratification of man in the Post-tertiary. To put it briefly, if insects have not a colour-sense, then the whole universe must be nothing more than a singularly happy concourse of fortuitous atoms."

Just as the varied hues of flowers are due to the selective action of insects, so the colouration of fruits must be sought in the reaction of birds and mammals. These, attracted by the colour no less than the odour of fruits, swallow the pulp, and void the hard, smooth, indigestible seeds with their excreta, placing them thus under highly favourable circumstances for germination. Hence the plant whose fruits assumed the most brilliant and striking colouration would gain a decided advantage in the struggle for existence.

On the fact that some poisonous, indigestible, or otherwise non-eatable fruits display a brilliant colouring much might be said did space permit. The author hazards the suggestion that some plants, such as the common arum and the manchineel, may derive a benefit from the poisonous property of their seeds, which if eaten by birds or small mammals might prove fatal, and "would thus have an opportunity of germinating in the midst of a rich manure heap formed of its decomposing body." We must remember, however, that poisonous seeds are avoided by most species and prove harmless to others.

Among the Mammalia, the author declares that the evidences of a colour-sense are mainly wanting. "The antipathy of male ruminants for scarlet," which he mentions,* seems to us to point to a tolerably well-developed recognition of colour. The bull, *e.g.*, must be able to discriminate between scarlet or blood-red and that reddish brown so common in his own species. If, however, the author's theory be correct, an absence of the colour-sense, save in monkeys, and perhaps squirrels, need not surprise us. No other mammals feed upon fruits or are very specially connected with flowers. This same deficiency, Mr. Allen considers, is the cause why mammals display none of the brilliant colouration so common in other departments of the animal kingdom. We cannot, however, refrain from pointing out that the golden mole, the only mammal endowed with fur of a metallic lustre, is certainly no fruit-eater.

Among flower- and fruit-feeding species in the most different groups of the animal kingdom the author considers that there prevails a community of tastes, in strongly-marked contrast to those of the Carnivora and the carrion-feeders. With this view, however, we cannot entirely agree. Many of the perfumes which are most agreeable to us are equally attractive to cats. Nothing seems to delight a leopard more than a saucer of lavender-water, and the common cat rolls in delight upon a number of plants which secrete essential oils, and which certainly have no connection with her ordinary diet.† On the other hand, many butterflies, though feeding ordinarily upon the nectar of flowers, may be attracted by odours of a most antagonistic character. Perhaps the easiest way to capture high-flying species, such as *Apatura Iris*, and the splended *Papilios* and *Ornithopteras* of sunnier climates, is to bait for them with excrement or carrion, such as a dead rat or a weasel. Many of our common native butterflies may be seen haunting manure-heaps and sipping the fœtid moisture.

To a certain passage in Mr. Wallace's "Tropical Nature,"‡ in which this illustrious biologist considers that an insect's capacity to distinguish colours may probably be quite unaccompanied by a sense of radical distinctness,

* Is this antipathy confined to males? Mr. Allen elsewhere remarks that dogs are attracted by bright colours.

† "Senses of the Lower Animals." (Quarterly Journal of Science, vol. viii., p. 297.)

‡ Page 238.

Mr. Allen takes exception in a passage which closely coincides with our remarks on the same subject.*

In a chapter on the "Direct Reaction of the Colour-Sense upon the Animal Integuments" the author proceeds to the demonstration of what we may call his initial law. He seeks to show, by a multitude of instances, that the most beautiful insects and birds are such as haunt flowers and fruits, either feeding directly upon their pollen, nectar, sweet juices, &c., or preying upon minute insects attracted there for the same purpose. He cites the observation repeatedly made by travelling naturalists, that where the flora is most beautiful the fauna is correspondingly splendid, whilst if the one is dingy and insignificant the same characters apply to the other. Exceptions will doubtless occur to the mind of the naturalist, especially if he be a student of insect-life. Thus though the author remarks, with much general truth, that "first in order of ugliness must be placed the carrion-feeders who live upon decaying bodies or animal excrements," yet if we look over a tolerably complete assortment of beetles of the great neo-tropical genus *Phaneus*—all, be it remembered, dung- and carrion-devourers—we find almost every variety of rich iridescent and metallic hues, emerald-greens, golden and ruddy bronzes, gorgeous blues, and purples. Great splendour may also be found among the *Coprides*, another group of filth-devourers; and even our common English dor-beetles show on their under surfaces pure and beautiful metallic hues. Sometimes, again, one and the same pattern or arrangement of colour may be traced in a number of species belonging to distinct groups, and feeding on substances of a totally different nature. For instances of this kind the reader is referred to the "Monthly Journal of Science" for February (p. 196). To the cases there mentioned may be added the death's-head moth, the convolvulus-hawk moth, &c. Mr. Allen himself refers to the tiger-beetles as exquisitely beautiful and highly carnivorous; and many other rapacious beetles, of the genera *Carabus*, *Calosoma*, *Pœcilus*, &c., are remarkable for the loveliness of their tints. Still we do not feel warranted in concluding that these apparent exceptions, and others which might be adduced, justify the rejection of Mr. Allen's law. Our knowledge of the diet and habits of insects is still very imperfect. Perhaps, too, the cases we have mentioned are "residual phenomena," which on further study will point the way to some further generalisation.

* Quarterly Journal of Science, vol. viii., p. 459.

In speaking of the generation of pigments Mr. Allen quotes with approval the declaration of Mr. Lowne,* that these substances are apparently due to the waste-products of other organs, and do not take away anything from the effective energies of the system. It might, perhaps, be asked how this view agrees with the one put forward in an earlier part of his work, where the production of colour is connected with the expenditure of energy? We fully admit the very high proportion of nitrogen present in feathers, and we recognise the fact that those animals—insects, birds, and reptiles—which are most richly coloured excrete uric acid to a notable extent. At the same time it must be admitted that the most beautiful colouring of such animals is due not to any pigment, but to the interference of light arising from the micro-mechanical texture of the feathers, wing-scales, elytra, &c.

Concerning "prohibitive" or "warning" colour, the author declares himself somewhat sceptical. As regards the eggs of birds he suggests that "the colouration may act as a supplementary allurement to the instinct of incubation." But how if the nest, as occurs in not a few species, such as the kingfisher, is absolutely dark within?

The concluding chapters of the work treat of the colour-sense in man, of the esthetic value of colour, and of the growth of the colour-vocabulary. By testimony collected through the aid of consuls, missionaries, and others, from semi-civilised and savage tribes, it is shown that the colour-sense is universal. By the evidence of gems and glass and stone beads, obtained from the lake-dwellings of Switzerland from barrows of the Stone Age, and of pottery from Dr. Schliemann's excavations at Mycæna, a cumulative proof is furnished that this same sense is of no recent growth.

* Philosophy of Education, p. 75.

II. EARLY TRACES OF MAN.*

By G. DE MORTILLET.

QUATERNARY MAN.—The man of geological time—fossil man—is now a fact so clearly demonstrated that it is no longer called in question. The recent exposition of anthropological sciences showed us his works *plentifully* scattered throughout France, England, Spain, and Italy.

But, though the existence of quaternary man in the south-west of Europe is no longer denied, there is a school which, walking with fear and hesitation in the path of progress, has its mind made up to contest his existence in the Orient. What the leaders of this school maintain is this:—In the East, say they, civilisation, and consequently historic records, date back to a very remote time. Is it not, then, possible that geological time still persisted in Europe, and especially in Western Europe, while in Egypt the historic dynasties were being founded?

To put forth such a proposition as this, one must be ignorant of the data of geology. The remarkable collections exhibited at the Anthropological Exposition have shown that man was contemporary not only with the reindeer, the saiga, the chamois, and the marmot on our plains; not only with the mammoth and the *Rhinoceros tichorhinus*,—that is, with the fauna of the Glacial period, but also with the great hippopotamus, the *Elephas primigenius*, and the rhinoceros of Merk. All geologists are agreed that the duration of the period in which we live is as nothing compared with that of the Quaternary period. It is as a day compared to ages, as a drop of water in a stream. All palæontologists understand what a length of time is requisite for the rise and decline of animal species—species which, while they have been upon the earth, have been lavishly distributed over an enormous area.

But we have no need of the general data of geology and palæontology in order to meet the objection. The Exposition of the Anthropological Sciences furnished materials which reduce it to a nullity. There were exhibited perfectly characterised quaternary instruments of silex from the East

* Translated by J. FITZGERALD, A.M., from the Revue d'Anthropologie.

—from the most ancient seats of civilisation, Egypt and Syria. In those countries, then, no less than in France and England, quaternary man preceded all the historic civilisations.

The earliest Quaternary epoch, the preglacial, is characterised, so far as man's works are concerned, by a stone implement of peculiar form. It is dressed on its two sides, usually rather roughly chipped; it is rounded at the base, pointed at the top, and its edges are pretty sharp. In general form it is more or less almond-shaped. This implement, in past times called by workmen in quarries "langue de chat" (cat's tongue), is now called "hache de St. Acheul," or "hache acheulienne" (hatchet of St. Acheul), terms derived from the locality in which it has been oftenest found. They have been found in abundance in the quaternary alluviums of France, England, and Spain. Nay, within a few years they have been found in the valley of the Delaware near Trenton, New Jersey, by Dr. Charles C. Abbott. The figures which he has published, and his descriptions, tally exactly with the St. Acheul hatchets of France and England.

Nor is it in the New World only that the existence of man in the earliest portion of the Quaternary period has been proved; the same thing is true of the Old World. M. Place, the explorer of Assyria, has brought to light a St. Acheul hatchet of silex which he found under the ruins of the palace of Khorsabad. At the Exposition the Abbé Richard showed a St. Acheul hatchet, also of silex, from the Lake of Tiberias.

A still more conclusive proof is furnished by Prof. Henry W. Haynes, of Boston, who reports a number of wrought flints from Egypt, among them several clearly characterised St. Acheul hatchets.

In the February number (1869) of the "Matériaux pour l'Histoire de l'Homme," M. Adrien Arcelin first made the announcement that the grand Egyptian civilisation, like all other civilisations, was preceded by an age of stone. He had just collected in Upper Egypt several clipped flints. Toward the close of the same year this discovery was confirmed by Messrs. Lenormant and Hamy. All the specimens brought home by these earliest explorers might be regarded as belonging to the Robenhausen epoch, or age of polished stone; only one specimen, presented to the museum of St. Germain, came anywhere near the St. Acheul type.

After Arcelin's discovery, collections of dressed flints were multiplied in Egypt, though without throwing much light upon the question. But Sir John Lubbock, in an essay

illustrated with fine plates, gave figures of three flint implements found at Luxor and at Abydos, which are undoubtedly St. Acheul hatchets.

Among the wrought flints brought from Egypt and exhibited by Mr. Haynes are several which incontestably are of the quaternary type. Among them we see scrapers and arrow-heads, the latter belonging to a type which in France occurs only in glacial formations. The collection also embraces more ancient forms, preglacial forms, referable to the early portion of the Quaternary period, viz., St. Acheul hatchets of flint.

These St. Acheul hatchets come from two very distinct localities: one lot is from the neighbourhood of Luxor, in Upper Egypt; the other from the environs of Cairo, in Lower Egypt. The flint used, as is clearly proved by Delanoue, comes from the nummulitic formations. These formations are found *in situ* in Upper Egypt; and the St. Acheul hatchets of that region are as a rule heavier and better wrought,—above all, more completely wrought. In the environs of Cairo there are no rocks *in situ;* and as for flint, only rounded nodules are found. These nodules have been wrought into the forms of implements. This is easily seen, for all the St. Acheul hatchets of that locality still bear at their base traces of the original rounded surface of the nodules.

From these archæological data—*i.e.*, from the nature and form of the objects—we may conclude that the man of the earliest Quaternary times lived in Egypt simultaneously with his existence in Europe, and that in both of these regions his industrial development was about the same, extremely primitive. And geological observation confirms these deductions. It was not on the surface of plateaus that Mr. Haynes found these St. Acheul implements. On the contrary, most of them, at least from the neighbourhood of Luxor (forming the greater number), were found in the bottom of the ravines of Bab-el-Moluk. These ravines are cut deep into the quaternary deposits by the torrents which, in seasons of heavy rainfall, carry to the Nile the waters from the mountains of Libya.

Thus, then, thanks to the Exposition of the Anthropological Sciences, we are in a position to show that the oldest Egyptian civilisation,—that of the earliest dynasties,—which dates back 4000 years before our era, was preceded by an age of polished stone, and that before that period Egypt, like all the rest of the world, was occupied by quaternary man.

Tertiary Man.—Important as are the results of the Anthropological Exposition from the point of view of quaternary man, they are still more so from the point of view of tertiary man.

But first let us understand what is meant by the terms quaternary and tertiary man.

The fauna of the mammals serves clearly to determine the limits of these later geological periods.

The Tertiary is characterised by terrestrial mammals entirely different from extant species; the Quaternary by the mingling of extant with extinct species; the present period by the extant fauna.

The man of the early Quaternary, he who made the St. Acheul hatchets and used them, is the man of Neanderthal, of Canstatt, of Enggisheim, of La Naulette, of Denise. He is indubitably a man, but differing more widely from the Australian and the Hottentot than the Australian and Hottentot differ from the European. Hence unquestionably he formed another human species, the word species being taken in the sense given to it by naturalists who do not accept the transformation doctrine.

Tertiary man, therefore, must have been still more distinct—of a species still less like the present human species; indeed, so different as to entitle it to be regarded as of distinct genus. For this reason I have given to this being the name of man's precursor. Or he might be called anthropopithecus—the man-monkey.

The question of Tertiary man should therefore be expressed thus:—Did there exist in the Tertiary age beings sufficiently intelligent to perform a part of the acts which are characteristic of man?

So stated, the question is settled most completely by the various series of objects sent to the Anthropological Exposition.

The first and oldest of these collections was that made by the late Abbé Bourgeois, at Thenay (Loir-et-Cher). At the International Congress of Prehistoric Archæology and Anthropology, held in Paris in 1867, the Abbé Bourgeois exhibited tertiary flints which, he claimed, had been chipped intentionally. These early specimens were not very conclusive, lost as they were amid a multitude of other specimens which certainly had not been fashioned intentionally, unless one can suppose that they had been intentionally split by the action of fire. The result was that the Abbé's communication won to his side but few adherents. But, profoundly convinced of the reality of his discovery, the Abbé Bourgeois

did not lose heart on suffering this partial repulse. He continued his researches with vigour, and again, in 1872, provided now with better specimens, he raised the question at the Brussels Congress. There he made some headway among the best experts. But on the commission which was specially appointed to examine the flints were several members who knew but very little directly about the manner of working on flint, and they either hesitated or passed an adverse judgment. Hence the question was not definitively settled. This result—half success, half failure—stimulated the ardour of the accomplished naturalist; he continued his investigations, and so succeeded in collecting for the Anthropological Exposition a remarkable series of flint implements which dispels all doubt.

This collection was made up of flints which beyond a doubt had undergone the action of fire. They are full of cracks, and even quite discoloured. With these are other flints, far more numerous, which have simply been split by fire. Among them are some which unquestionably have been neatly and regularly retouched on one or both of their margins. Every one who has carefully and impartially examined them has admitted that the second dressing (*les retailles*) was certainly intentional, and consequently that it was the work of an intelligent creature.

It remains to determine the age to which these flints belong. They were collected at Thenay, in formations clearly *in situ* and intact, and belonging to the formation known among geologists as "calcaires de Beauce;" but now these calcaires de Beauce constitute the lower strata of the Middle Tertiary. This is shown by the fauna which the Abbé Bourgeois exhibited in connection with the flints. This fauna, which comes from the sands of the Orléanais, which directly overlie the calcaires de Beauce, comprises great mastodons and dinotheriums belonging to the Lower Miocene. Then there is the acerotherium, a genus akin to the rhinoceros, and which was found in the very same stratum as the fire-split and re-dressed flints.

It results, therefore, from the Abbé Bourgeois's researches, that during the Middle Tertiary there existed a creature, precursor of man, an anthropopithecus, which was acquainted with fire and could make use of it for splitting flints. It also knew how to trim the flint-flakes thus produced and to convert them into tools.

This curious and interesting discovery for a long time stood alone, and arguments were even drawn from this

isolatedness to favour its rejection. Fortunately another French observer, M. J. B. Rames, has found in the vicinity of Aurillac (Cantal), in the strata of the upper part of the Middle Tertiary,—here, too, in company with mastodons and dinotheriums, though of more recent species than those of Thenay,—flints which also have been re-dressed intentionally. Here, however, the flints are no longer split by fire, but by tapping. It is something more than a continuation, it is a development. Among the few specimens exhibited by M. Rames, whose discoveries are quite recent, is one which, had it been found on the surface of the ground, would never have been called in question.

The weighty facts developed by French investigators received striking confirmation in the Portuguese department of the Exposition. A distinguished *savant* of Lisbon, Senhor Ribeiro, director of the Geological Bureau of Portugal, sent a collection of flints and quartzites found in the strata of the Middle Tertiary or Miocene, and in the Upper Tertiary or Pliocene of the valley of the Tagus. Among these specimens—ninety-five in number—are twenty-two which bear unquestionable traces of intentional chipping. Nine specimens, all of flint, are described as coming from the Miocene. Of the others, purporting to be Pliocene, seven are of flint and six of quartzite. All these specimens are roughly chipped, and nearly all are triangular in form, and not redressed, whether the material be flint or quartzite.

Thus, then, the Anthropological Exposition, important though it was from the point of view of Quaternary man, is still more important from the point of view of Tertiary man —man's precursor. His existence can no more be denied.—*Popular Science Monthly.*

III. LEAVES AND THEIR FUNCTIONS.

By Rev. L. J. Templin, Hutchinson, Kas.

A LEAF, whatever may be its configuration or colour, is always an object of interest. But how few people, when they see a leaf as it waves and flutters in the breeze, really know what they are looking at. Leaves appear in an endless variety of forms, sizes, and colours. They are often so transformed that it is more by the place they occupy

than by their forms that we know they are leaves. Underground stems or rhizomas have them at each point or node as little thin scales. Buds are enveloped in peculiar cerements, which generally fall away soon after the ordinary leaves have begun to expand; those enveloping scales are only leaves in a modified form. They are quite prominent in the hickory and horse-chestnut. The scales of bulbs, as of the lily, are simply modified leaves. Flowers are only aggregations of metamorphosed leaves. But it is with leaves as foliage that we are more immediately concerned at present. A complete leaf consists of three parts—the stalk or stem (petiole) on which it rises, the expanded blade or lamina, and two small leaf-like appendages at the base of the leaf-stalk called stipules. The only essential part is the blade, as this may be sessile on the stem without petiole or stipules. The blade of a leaf consists of three portions:—the woody framework, ribs, or veins; the green cellular portion, pulp; and the outside covering, or epidermis. The epidermis, which is really an extension of the outer bark of the stem, is composed of closely united, transparent cells, with frequent openings through it called stomata or breathing-pores. These vary in number from 800 to 170,000 to the square inch of surface. It is through these that water is exhaled from the plant. They are more numerous in the leaves of plants growing in moist situations and surrounded by a damp atmosphere. The pores dilate with the increase of humidity and contract with the increase of aridity. Plants growing in arid climates have but few stomata, and these are very small. While the most of foliage appears to be made on the principle of exposing the greatest possible surface to the air, some forms of vegetation seem to be constructed for the accomplishment of the very reverse of this. Thus the various species of *Cactus*, whose native habitat is the hot, arid plains of the South-west, are constructed on the principle of presenting the least extent of surface to the air, and this surface is covered with an epidermis that is almost impervious to water. This is necessary to prevent excessive transpiration in that very dry climate. The pulp or parenchyma of the leaf is made up of several layers of cells. These cells are small globular sacs, varying from 1-1200th to 1-250th of an inch in diameter. A layer of these, of a rather elongated form, is arranged immediately beneath the epidermis of the upper side of the leaf with the ends to the surface. These are crowded quite closely together. Another layer, not quite so much elongated and less compactly arranged, is found on

the under side of the leaf. Between these two layers are numerous globular cells that seem thrown together without any great regularity or order. Among these are numerous irregular passages, intercellular spaces, through which water and air circulate. These reach the surface through the stomata of the epidermis. It is worthy of notice that by far the larger part of these breathing pores are on the under surface, and this surface always seems to avoid direct sunshine. If a leaf is inverted, turning the bottom side upward, it will, if possible, return to its natural position, and if prevented from so doing it will soon die. A few leaves have been known to grow in a vertical instead of a horizontal position. The framework of leaves consists of wood, and is intended to give firmness and support to the leaf. It is divided into numerous veins or nerves that ramify every part of the green parenchyma. There are two distinct systems of venation of leaves—the parallel-veined and the net-veined. In the former the fibres run nearly parallel from one extremity of the leaf to the other; such leaves are usually long and narrow, linear, as in the grasses, corn, &c. In the other the veins are netted, ramifying the leaf in all directions, and dividing the parenchyma into numerous small squares and diamonds. This style of venation exists under two forms: in one a principal vein, midrib, extends from the base to the apex of the leaf, and from this numerous smaller veins branch off and run to the margin; in the other there are three or five nearly equal ribs running the length of the leaf. The first is feather-veined, from its resemblance to a feather; and the other is palmately veined, the main ribs branching out like the fingers of a hand. The shape of a leaf is generally determined by the manner of its venation. The two principal styles of venation belong to and denote two different classes of plants, the parallel-veined belonging to the monocotyledonous, and the net-veined to the dicotyledonous divisions of the vegetable kingdom. Thus the veining of a small portion of a leaf will indicate to which of these classes the plant upon which it grew belonged.

The green colour of leaves comes from a granular substance, chlorophyll, found in the cells of the parenchyma. In its absence no true vegetable structure can be built up from the original elements, and it can operate only in the presence of sunlight. Low cryptogamic plants will grow in the dark, but they contain no proper chlorophyll. Chlorophyll has been found to be composed of two different substances,—xanthophyll, a yellow substance, and cyanophyll,

a blue material: their union forms chlorophyll, or leaf-green. It is thought that the yellow colour of leaves at maturity is caused by the predominance of xanthophyll at that time. Besides chlorophyll the leaf-cells contain the proximate principles of the plant; and here the real work of building plant structure is performed. But this brings us to the consideration of the second part of our subject, viz., the functions of leaves.

In treating this branch of the subject it will be necessary to consider the leaf under several different characters. Leaves should be considered as real living beings, capable of performing vital functions—as workers performing a large amount of important work. We may first consider *the leaf as a pump*. One of its most important offices is to pump up water from the soil through the roots and stems of plants. This it exhales through its stomata in the form of invisible vapour. By this means a large quantity of water is carried up from the soil to the atmosphere. Thus a large portion of water that would quickly settle down through the deeper soil, and find its way into underground passages, is carried up and given off to the atmosphere, where it is condensed into clouds and descends in rain, thus watering and making fruitful the earth. Without this work many parts of the earth that now blossom as the rose would become arid wastes. The amount of moisture thus carried up and exhaled by the foliage of trees and plants is immense. A sunflower, with a leaf surface of 39 square feet, exhaled 3 lbs. of water in twenty-four hours. A corn plant, in about three and a half months, gave off in vapour thirty-six times its own weight of water. A medium-sized forest tree will pump up and exhale about 5 barrels of water in twenty-four hours: this will give about 800 barrels to the acre. An acre of grain or grass will do about the same. From this it may be seen why forests exert such a powerful influence on the rainfall of a country.

Again, we may consider *the leaf as a lightning conductor*. It is one of the most efficient conductors of electricity ever made. Most leaves have notched edges; each of these "points" is powerful to attract the electric fluid from the air, and through the stem convey it silently to the ground. A single blade of grass is said to be three times as powerful to attract electricity as a fine cambric needle, and a twig covered with leaves is more efficient than the best constructed "patent point." A tree covered with leaves is the most efficient safeguard from lightning that can be found.

A green tree is constantly conveying electricity from the

earth to the air and from the air to the earth. True, it sometimes tries to carry too large a load in response to the efficient collecting power of the leaves. They gather it in faster than the trunk can carry it away, and it is burst. We say the tree is struck with lightning; but it has often been struck before, but this time it was overloaded and crushed. Trees are natural lightning-rods, more efficient than all the artificial ones that have ever been invented.

In the next place we may contemplate *the leaf as an organiser* of organic matter. It is here that it has performed its most efficient and important service for man. Through its agency every particle of both vegetable and animal organism has been either directly or indirectly built up. Every plant, tree, and shrub has been directly built up through the labour of the leaf. And even long before the present order of things existed the leaf was at work: through its labours vast beds of vegetable matter were laid away far back in the carboniferous ages, which by heat and pressure have become coal, forming vast storehouses of excellent fuel. And still farther back, in times when Silurian seas washed the shores of limited bodies of land, the leaf was at earnest, ceaseless toil. Thus we owe to the leaf not only what makes life pleasant, but our food and raiment and fuel, without which life would be impossible. Without the leaf as an organiser the earth would sink back into a lifeless, pulseless waste.

Lastly, we may consider *the leaf as a chemical agent*, withdrawing and consolidating various poisonous gases, which if left in the air would render it unfit to sustain life, and thus convert the earth into one vast charnel-house of the dead. The air contains 1-2500th of its own bulk of carbonic acid, consisting of two equivalents of oxygen and one of carbon. This gas is a deadly foe to animal life, and if permitted to accumulate in the air would soon render it unfit to sustain life. And yet there are certain processes constantly going on that tend to augment the proportion of this gas in the atmosphere. Every breath of every human being and every living animal, and every bit of fuel that is consumed, and every particle of vegetable matter that decays, and every volcano that sends forth its deadly fumes, are adding to the quantity of this gas in the atmosphere. By what agency, then, is the equilibrium maintained? It is through the agency of our little friend the leaf that the work so essential to life and health is performed. It is constantly employed as an analytic chemist imbibing this poisonous gas and analysing it, using the carbon to build up the organic sub-

stance of its own structure, and giving up the healthful, life-giving oxygen to the atmosphere again. This process is so regulated as exactly to keep pace with the liberation of carbonic acid through the agencies mentioned above. Other deleterious gases are thus taken in and rendered innocuous. The blue gum (*Eucalyptus globulus*), of Australia, has become famous for absorbing the deadly gases in miasmatic districts, and thus rendering them healthy. Thus the leaf labours preparing food for all living animals, and raiment and fuel for the lords of creation, as well as all wood and bone and ivory used in the arts. It also purifies the air, making animal life possible, and clothing the earth with beauty that the life thus preserved may be replete with the highest enjoyment.—*Kansas City Review of Science and Industry.*

IV. MOLECULAR PHYSICS IN HIGH VACUA.*

By William Crookes, F.R.S.

WHEN I was asked, a month or two ago, to illustrate in this theatre some of my recent researches on Molecular Physics in High Vacua, I exclaimed "How is it possible to bring such a subject worthily before a Royal Institution audience when none of the experiments can be seen more than three feet off?" If to-night I am fortunate enough to show all the experiments to those who are not far distant, and if I succeed in making most of them visible at the far end of the theatre, such a success will be entirely due to the great kindness of your late Secretary, Mr. Spottiswoode, who has placed at my disposal his magnificent induction-coil,—not only for this lecture, but for some weeks past in my own Laboratory,—thus enabling me to prepare apparatus and vacuum tubes on a scale so large as to relieve me of all anxiety so far as the experimental illustrations are concerned.

Before describing the special researches in molecular physics which I propose to illustrate this evening, it is necessary to give a brief outline of one small department of the modern theory of the constitution of gases.

* A short-hand report of a Lecture delivered at the Royal Institution, on Friday, April 4, 1879.

It is not easy to make clear the kinetic theory, but I will try to simplify it in this way:—Imagine that I have in a large box a swarm of bees, each bee independent of its fellow, flying about in all manner of directions and with very different velocities. The bees are so crowded that they can only fly a very short distance without coming into contact with one another or with the sides of the box. As they are constantly in collision, so they rebound from each other with altered velocities and in different directions, and when these collisions take place against the sides of the box pressure is produced. If I take some of the bees out of the box, the distance which each individual bee will be able to fly before it comes into contact with its neighbour will be greater than when the box was full of bees, and if I remove a great many of the bees I increase to a considerable extent the average distance that each can fly without a collision. This distance I will call the bee's *mean free path*. When the bees are numerous the mean free path is very short; when the bees are few the mean free path will be longer, the length being inversely proportional to the number of bees present. Let us now imagine a loose diaphragm to be introduced in the centre of the box, so as to divide the number of bees equally. The same number of bees being on each side, the impacts on the diaphragm will be equal; and the mean speed of the bees being the same, the pressure will be identical on each side of the diaphragm, and it will not move.

Let me now warm one side of this division so as to let it communicate extra energy to a bee when it touches it. As before, a bee will strike the diaphragm with its normal mean velocity, but will be driven back with extra velocity, the reaction producing an increase of pressure on the diaphragm. It will be found, however, that although the diaphragm is free to move, the extra strength of the recoil on the warm side does not produce any motion. This at first sight seems contrary to the law of action and reaction being equal. The explanation is not difficult to understand. The bees which fly away from the diaphragm have drawn energy from it, and therefore move quicker than those which are coming towards it; they beat back the crowd to a greater distance, and keep a greater number from striking the diaphragm. Near to the heated side of the diaphragm the density is less than the average, while beyond the free path the density is above the average, and this greater crowding extends to all other parts of the box.

Thus it happens that the extra energy of the impacts against the warm side of the diaphragm is exactly compensated by the increased number of impacts on the cool side. In spite therefore of the increased activity communicated to a portion of the bees, the pressure on the two sides of the diaphragm will remain the same. This represents what occurs when the extent of the box containing the bees is so great, compared with the mean free path, that the abrupt change in the velocities of those bees which rebound from the walls of the box produces only an insensible influence on the motions of bees at so great a distance as the diaphragm.

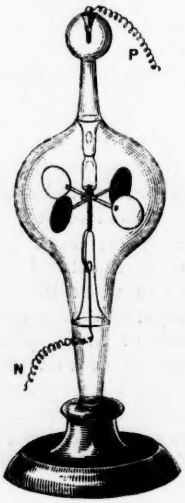
I will next ask you to imagine that I am gradually removing bees from our box, still keeping the diaphragm warm on one side. The bees getting fewer the collisions will become less frequent, and the distance each bee can fly before striking its neighbour will get longer and longer, and the crowding in front of them will grow less and less. The compensation will also diminish, and the warmed side of the diaphragm will have a tendency to be beaten back. A point will at last be reached on the warm side, when the mean free path of the bees will be long enough to admit of their dashing right across from the diaphragm to the side of the box, without meeting more than a certain number of in-coming bees in their flight. In this case the bees will no longer fly quite in the same direction as before. They will now fly less sideways, and more forwards and backwards between the heated face of the diaphragm and the opposed wall of the box. Because of this preponderating motion, and also because they will thereby less effectually keep back bees crowding in from the sides, there will now be a greater proportionate pressure both on the hot face of the diaphragm and on that part of the box which is in front of it. Hence the pressure on the hot side will now exceed that on the cool side of the diaphragm, which will consequently have a backward movement communicated to it.

I may diminish the size of the bees as much as I like, and by correspondingly increasing their number the mean free path will remain the same. Instead of bees let me call them molecules, and instead of having a few hundreds or thousands in the box let me have millions and billions and trillions; and if we also diminish the mean free path to a considerable extent, we get a rough outline of the kinetic theory of gases. (I may just mention that the mean free path of the molecules in air, at the ordinary pressure, is the ten-thousandth of a millimetre.)

Three years ago I had the honour of bringing before you the results of some researches on the Radiometer. Let me now take up the subject where I then left off. I have here two radiometers which have been rotating before you under the influence of a strong light shining upon them.

The explanation of the movement of the radiometer is this,—the light, or the total bundle of rays included in the term "light," falling upon the blackened side of the vanes, becomes absorbed, and thereby raises the temperature of the black side: this causes extra excitement of the air molecules which come in contact with it, and pressure is produced, causing the fly of the radiometer to turn round.

FIG. 1.



I have long believed that a well-known appearance observed in vacuum tubes is closely related to the phenomena of the mean free path of the molecules. When the negative pole is examined while the discharge from an induction-coil is passing through an exhausted tube, a dark space is seen to surround it. This dark space is found to increase and diminish as the vacuum is varied, in the same way that the ideal layer of molecular pressure in the radiometer increases and diminishes. As the one is perceived by the mind's eye to get greater, so the other is seen by the bodily eye to increase in size. If the vacuum is insufficient to permit the

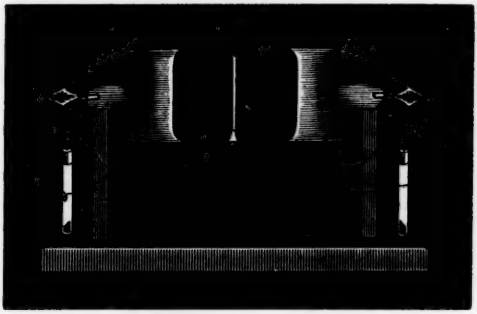
radiometer to turn, the passage of electricity shows that the "dark space" has shrunk to small dimensions. It is a natural inference that the dark space is the mean free path of the molecules of the residual gas.

The radiometer which has just been turning under the influence of the lime-light is not of the ordinary kind. Fig. 1 will explain its construction.

It is similar to an ordinary radiometer with aluminium disks for vanes, each disk coated on one side with a film of mica. The fly is supported by a hard steel instead of glass cup, and the needle point on which it works is connected by means of a wire with a platinum terminal sealed into the glass. At the top of the radiometer bulb a second terminal is sealed in. The radiometer can therefore be connected with an induction-coil, the movable fly being made the negative pole.

As soon as the pressure is reduced to a few millims. of mercury, a halo of velvety violet light forms on the

FIG. 2.



metallic side of the vanes, the mica side remaining dark. As the pressure diminishes, a dark space is seen to separate the violet halo from the metal. At a pressure of half a millim. this dark space extends to the glass, and positive rotation commences. On continuing the exhaustion the dark space further widens out and appears to flatten itself against the glass, when the rotation becomes very rapid.

You perceive a dark space behind each vane and moving round with it. In the first experiment, radiation from the lime-light falling on the metallic sides of the vanes, produced a layer of molecular pressure which drove the fly

round; so here the induction-current has produced molecular excitement at the surface of the vanes forming the negative pole, extending up to the side of the glass.

When the negative pole is in rapid rotation it is not easy to see this dark space, so I have arranged a tube in which the dark space will be visible to all present. The tube, as you will see by the diagram (Fig. 2), has a pole in the centre in the form of a metal disk, and other poles at each end. The centre pole is made negative, and the two end poles connected together are made the positive terminal. The dark space will be in the centre. When the exhaustion is not very great the dark space extends only a little distance on each side of the negative pole in the centre. When the exhaustion is very good, as it is in the tube before you, and I turn on the coil, the dark space is seen to extend for about 2 inches on each side of the pole.

Here, then, we see the induction spark actually illuminating the lines of molecular pressure caused by the excitement of the negative pole. The thickness of this dark space—nearly 2 inches—is the measure of the mean free path between successive collisions of the molecules of the residual gas. The extra velocity with which the negatively electrified molecules rebound from the excited pole keeps back the more slowly moving molecules which are advancing towards that pole. The conflict occurs at the boundary of the dark space, where the luminous margin bears witness to the energy of the discharge.

I will endeavour to throw on the screen an illustration of this dark space. A stream of water falls from a small jet on to a horizontal plate of glass. The water spreads over the plate and forms a thin film. The jet of water in the centre, from the velocity of its fall, drives the film of water before it on all sides, raising it into a ring-shaped heap. As I diminish the force of the jet the ring contracts: this is equivalent to the exhaustion getting less. When I increase the force of water the ring expands in size, the effect being analogous to an increase of exhaustion in my tubes. The extra velocity of the falling particles of water drive the in-coming particles of water before them, and raises a ridge round the side which exactly represents the luminous halo to the dark space to be seen in this tube.

If, instead of a flat disk, a metal cup is used for the negative pole, the successive appearances on exhausting the tube are somewhat different. The velvety violet halo forms over each side of the cup. On increasing the exhaustion the dark space widens out, retaining almost exactly

the shape of the cup. The bright margin of the dark space becomes concentrated at the concave side of the cup to a luminous focus, and widens out at the convex side. When the dark space is very much larger than the cup, its outline forms an irregular ellipsoid drawn in towards the focal point. Inside the luminous boundary a dark violet light can be seen converging to a focus, and, as the rays diverge on the other side of the focus, spreading beyond the margin of the dark space; the whole appearance being strikingly similar

Fig. 3.

to the rays of the sun reflected from a concave mirror through a foggy atmosphere. This proves a somewhat important point; it shows that the molecules thrown off the excited negative pole leave it in a direction almost normal to the surface.

I can illustrate this property of the molecular rays by an experiment. This diagram (Fig. 3) is a representation of the tube which is before you. It contains, as a negative pole, a hemi-cylinder (*a*) of polished aluminium. This is connected with a fine copper wire, *b*, ending at the platinum terminal, *c*. At the upper

end of the tube is another terminal, *d*. The induction-coil is connected so that the hemi-cylinder is negative and the upper pole positive, and when exhausted to a sufficient extent, as is the case with this tube, the projection of the molecular rays to a focus is very beautifully shown. The rays are driven from the hemi-cylinder in a direction normal to its surface; they come to a focus and then diverge, tracing their path in brilliant green phosphorescence on the surface of the glass.

You will notice that the rays which project from the negative pole and cross in the centre have a bright green appearance; that colour is entirely due to the phosphorescence of the glass. At a very high exhaustion the phenomena noticed in ordinary vacuum tubes when the induction spark passes through them—an appearance of cloudy luminosity and of stratifications—disappears entirely. No cloud or fog whatever is seen in the body of the tube, and with such a vacuum as I am working with in these experiments—about a

FIG. 4.

millionth part of an atmosphere—the inner surface of the glass glows with a rich green phosphorescence, the intensity of colour varying with the perfection of the vacuum. It scarcely begins to show much before the 800,000th of an atmosphere. At about a millionth of an atmosphere the phosphorescence is very strong, and after that it begins to diminish until there are not enough molecules left to allow the spark to pass.*

I have here a tube which will serve to illustrate the dependence of the green phosphorescence of the glass on the degree of perfection of the vacuum (Fig. 4). The two poles are at *a* and *b*, and at the end (*c*) is a small supplementary tube connected with the other by a narrow aperture, and containing solid caustic potash. The tube has been exhausted to a very high point, and the potash heated so as to drive off moisture and deteriorate the vacuum.

* 1·0 millionth of an atmosphere = 0·00076 millim.
1315·789 millionths of an atmosphere = 1·0 millim.
1,000,000 " " " = 760·0 millims.
" " " " = 1 atmosphere.

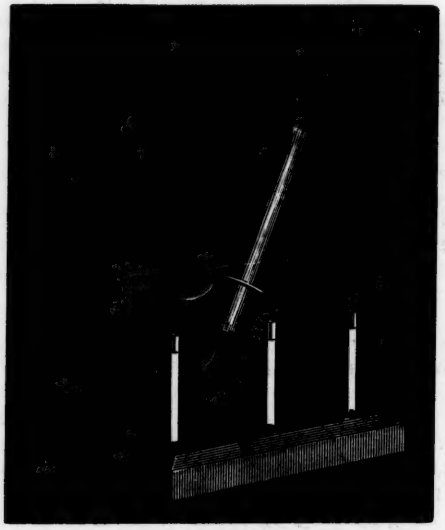
Exhaustion has then been re-commenced, and the alternate heating and exhaustion have been repeated until the tube has been brought to the state in which it now appears before you. When the induction spark is first turned on nothing is visible—the vacuum is so high that the tube is non-conducting. I now warm the potash slightly, and liberate a trace of aqueous vapour. Instantly conduction commences, and the green phosphorescence flashes out along the length of the tube. I continue the heat, so as to drive off more gas from the potash. The green gets fainter, and now a wave of cloudy luminosity sweeps over the tube, and stratifications appear. These rapidly get narrower, until the spark passes along the tube in the form of a narrow purple line. I take the lamp away, and allow the potash to cool; as it cools, the aqueous vapour, which the heat had driven off, is re-absorbed. The purple line broadens out, and breaks up into fine stratifications; these get wider, and travel towards the potash tube. Now a wave of green light appears on the glass at the other end, sweeping on and driving the last pale stratification into the potash; and now the tube glows over its whole length with the green phosphorescence. Would time allow I might keep it before you, and show the green growing fainter and the vacuum becoming non-conducting; but time is required for the absorption of the last traces of vapour by the potash, and I must pass on to the next subject.

This green phosphorescence is a subject that has much occupied my thoughts, and I have striven to ascertain some of the laws governing its occurrence. I soon perceived that the phosphorescence was not in the body of the tube itself, but was entirely on the surface of the glass. Another peculiarity of the rays producing this green phosphorescence is that they will not turn a corner in the slightest degree. Here is a V-shaped tube (Fig. 5), a pole being at each extremity. The pole at the right side (*a*) being negative, you see that the whole of the right arm is flooded with green light, but at the bottom it stops sharply, and will not turn the corner to get into the left side. When I reverse the current, and make the left pole negative, the green changes to the left side, always following the negative pole, leaving the positive side with scarcely any luminosity.

In the ordinary phenomena exhibited by vacuum tubes—phenomena with which we are all familiar—it is customary, for the more striking illustration of their contrasts of colour, to have the tubes bent into very elaborate designs. The positive luminosity caused by the phosphorescence of the

residual gas follows all the convolutions and designs into which skilful glass-blowers can manage to twist the glass. The negative pole being at one end and the positive pole at the other, the luminous phenomena seem to depend more on the positive than on the negative at an ordinary exhaustion such as has hitherto been used to get

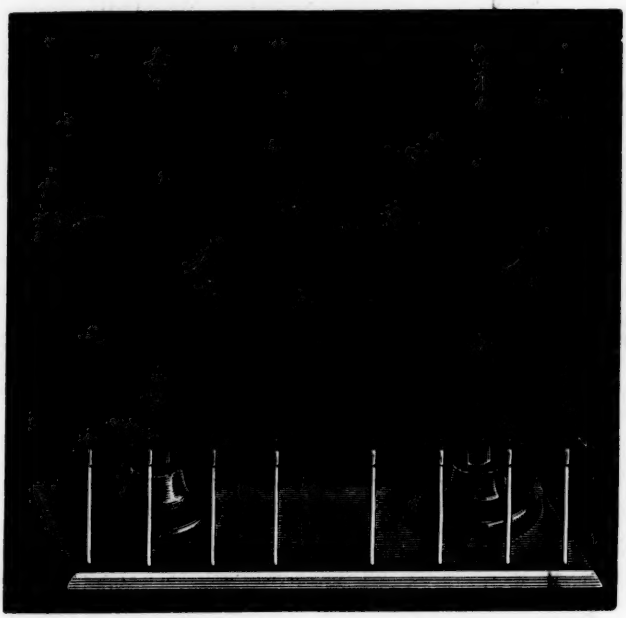
FIG. 5.



the best phenomena of vacuum tubes. I have here two bulbs (Fig. 6), alike in shape and position of poles, the only difference being that one is at an exhaustion equal to a few millimetres of mercury,—such a moderate exhaustion as will give stratifications or the ordinary luminous phenomena,—whilst the other is exhausted to about the millionth of an atmosphere. I will first connect the moderately exhausted bulb with the induction-coil, and, retaining the pole at one side (*a*) always negative, I will put the positive wire successively to the other three poles with which the bulb is furnished. You will see that as I change the position of the positive pole, the line of violet light joining the two poles changes. In this moderately exhausted bulb, therefore, the electric current always chooses the shortest path between the two poles, and moves about the bulb as I alter the position of the wires.

This, then, is the kind of phenomenon we get in ordinary exhaustions. I will now try the same experiment with a tube that is highly exhausted, and, as before, will make the side pole (*a'*) the negative, the top pole (*b*) being positive. Notice how widely different is the appearance from that shown by the last bulb. The negative pole is in the

FIG. 6.



form of a shallow cup. The bundle of rays from the cup crosses in the centre of the bulb, and thence diverging falls on the opposite side as a circular patch of green light. As I turn the bulb round you will all be able to see the faint blue focus and the green patch on the glass. Now observe, I remove the positive wire from the top, and connect it with the side pole (*c*). The green patch from the divergent negative focus is still there. I now make the lowest pole (*d*) positive, and the green patch still remains where it was at first, unchanged in position or intensity.

This, then, gives us another fact which brings us a little nearer to the cause of this green phosphorescence. It is this—

that in the low vacuum the position of the positive pole is of every importance, whilst in a high vacuum it scarcely matters at all where the positive pole is; the phenomena seem to depend entirely on the negative pole. In very high vacua, such as we have been using, the phenomena follow altogether the negative pole. If the negative pole points in the direction of the positive, all very well, but if the negative pole is entirely in the opposite direction it does not matter: the line of rays is projected all the same in a straight line from the negative.

I have hitherto spoken of and illustrated these phenomena in connection with *green* phosphorescence. It does not follow, however, that the phosphorescence is always of that colour. This colouration is a property of the particular kind of glass in use in my laboratory. I have here (Fig. 7) three bulbs composed of different glass: one is uranium glass (*a*), which phosphoresces of a dark green colour; another is English glass (*b*), which phosphoresces of a blue colour; and the third (*c*) is soft German glass,—of which most of the apparatus before you is made,—which phosphoresces of a bright apple-green colour. It is therefore plain that this particular green phosphorescence is solely due to the glass which I am using. Were I to use English glass I should have to speak of blue phosphorescence, but I know of no glass which is equal to the German in brilliancy.

Fig. 7.

My earlier experiments were almost entirely carried on by the aid of the phosphorescence which glass takes up when it is under the influence of the electric discharge *in vacuo;* but many other substances possess this phosphorescent power, and some have it in a much higher degree than glass. For instance, here is some of the luminous sulphide of calcium prepared according to M. Ed. Becquerel's description. When it is exposed to light—even candlelight—it

phosphoresces for hours with a rich blue colour. I have prepared a diagram with large letters written in this luminous sulphide; before it is exposed to the light the letters are invisible, but Mr. Gimingham has just exposed it in another room to burning magnesium, and now it is

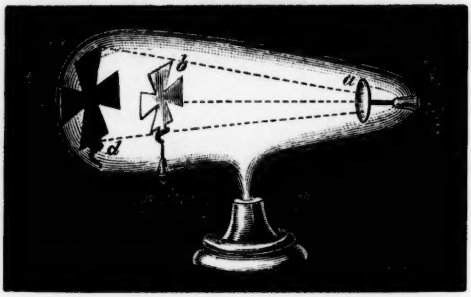
FIG. 8.

brought into the darkened theatre you will see the word "φως,"—*light*, a very suitable word for so beautiful a phosphorescence—shining brightly in luminous characters. The first letter, φ, shines with an orange light; it is a sulphide of calcium prepared from oyster-shells. The other letters, shining with a blue light, are sulphide of calcium prepared from precipitated carbonate of lime. Once the phosphorescence is excited the letters shine for several hours. I will put the diagram at the back, and we shall see how it lasts during the remainder of the lecture. This substance, then, is phosphorescent to light, but

it is also much more strongly phosphorescent to the molecular discharge in a good vacuum, as you will see when I pass the discharge through this tube (Fig. 8). The white plate (*a*, *b*) in the centre of the tube is a sheet of mica painted over with the luminous sulphide of which the letter ϕ was composed in the diagram you have just seen. On connecting the poles with the coil, the mica screen glows with a strong yellowish green light, bright enough to illuminate all the apparatus near it. But there is another phenomenon to which I now desire to draw attention: on the luminous screen is a kind of distorted star-shaped figure. A little in front of the negative pole I have fixed a star (*c*) cut out in aluminium, and it is the image of this star which you see on the screen. It is evident that the rays coming from the negative pole project an image of anything that happens to be in front of it. The discharge, therefore, must come from the pole in straight lines, and does not merely permeate all parts of the tube and fill it with light as it would were the exhaustion less good. Where there is nothing in the way the rays strike the screen and produce phosphorescence, and where there is an obstacle they are obstructed by it, and a shadow is thrown on the screen. I shall have more to say about this shadow presently; I merely now wish to establish the fact that these rays driven from the negative pole produce a shadow.

I must draw your attention to an important experiment connected with these molecular rays, but unfortunately it is a very delicate one, and very difficult to show to many at once; but I hope, if you know beforehand what

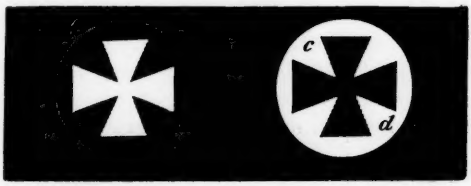
FIG. 9A.



to look for, you will all be able to see what I wish to show. In this pear-shaped bulb (Fig. 9 A) the negative pole (*a*) is at the pointed end. In the middle is a cross (*b*)

cut out of sheet aluminium, so that the rays from the negative pole projected along the tube will be partly intercepted by the aluminium cross, and will project an image of it on the hemispherical end of the tube which is phosphorescent. I think you will all now see the shadow of the cross on the end of the bulb (*c*, *d*), and notice that the cross is black on a luminous ground. Now, the rays from the negative pole have been passing by the side of the aluminium cross to produce the shadow; they have been hammering and bombarding the glass till it is appreciably warm, and at the same time they have been producing another effect on that glass—they have deadened its sensibility. The glass has got tired, if I may use the expression, by the enforced phosphorescence. Some change has been produced by this bombardment which will prevent the glass from responding easily to additional excitement; but the part that the shadow has fallen on is not tired—it has not been phosphorescing at all and is perfectly fresh; therefore if I throw this star down,—I can easily do so by giving the apparatus a slight jerk, for it has been most ingeniously constructed with a hinge by Mr. Gimingham,—and so allow the rays from the negative pole to fall uninterruptedly on to the end of the bulb, you will suddenly see the black cross (*c*, *d*, Fig. 9B) change to a luminous one (*e*, *f*), because the back-

FIG. 9 B.



ground is only faintly phosphorescing, whilst the part which had the black shadow on it retains its full phosphorescent power. The luminous cross is now dying out. This is a most delicate and venturous experiment, and I am fortunate in having succeeded so well, for it is one that cannot be rehearsed. After resting for a time the glass seems to partly recover its power of phosphorescing, but it is never so good as it was at first.

We have, therefore, found an important fact connected with this phosphorescence. Something is projected from the negative pole which has the power of hammering away at the glass in front of it, in such a way as to cause it not

only to vibrate and become temporarily luminous while the discharge is going on, but to produce an impression upon the glass which is permanent. The explanation which has gradually evolved itself from this series of experiments is this:—The exhaustion in these tubes is so high that the dark space, as I showed you at the commencement of this Lecture, that extended around the negative pole, has widened out till it entirely fills the tube. By great rarefaction the mean free path has become so long that the hits in a given time may be disregarded in comparison to the misses, and the average molecule is now allowed to obey its own motions or laws without interference. The mean free path is in fact comparable to the dimensions of the vessel, and we have no longer to deal with a *continuous* portion of matter, as we should were the tubes less highly exhausted, but we must here contemplate the molecules *individually*. At first this was only a convenient working hypothesis. Long-continued experiment then raised this provisional hypothesis almost to the dignity of a theory, and now the general opinion is that this theory gives a fairly correct explanation of the facts. In these highly exhausted vessels the mean free path of the residual molecules of gas is so long that they are able to drive across from the pole to the other side of the tube with comparatively few collisions. The negatively electrified molecules of the gaseous residue in the tube therefore dash against anything that is in front, and cast shadows of obstacles just as if they were rays of light. Where they strike the glass they are stopped, and the production of light accompanies this sudden arrest of velocity.

Other substances besides English, German, and uranium glass, and Becquerel's luminous sulphides, are also phosphorescent. I think, without exception, the diamond is the most sensitive substance I have yet met for ready and brilliant phosphorescence. I have here a tube, similar to those already exhibited, containing a mica screen painted with powdered diamond, and when I turn on the coil, the brilliant blue phosphorescence of the diamond can be seen, quite overpowering the green phosphorescence of the glass. Here, again, is a very curious diamond, which I was fortunate enough to meet with a short time ago. By daylight it is green, produced, I fancy, by an internal fluorescence. The diamond is mounted in the centre of this exhausted bulb (Fig. 10), and the negative discharge will be directed on it from below upwards. On darkening the theatre you see the diamond shines with as much light as a candle, phosphorescing of a bright green.

In this other bulb is a remarkable collection of crystals of diamonds, which have been lent me by Professor Maskelyne. When I pass the discharge over them I am

FIG. 10.

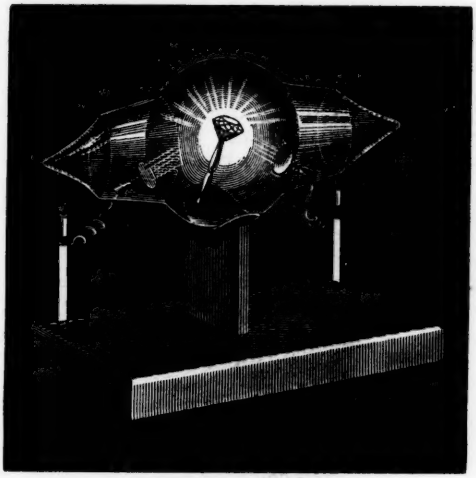
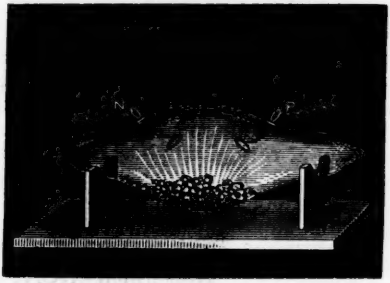


FIG. 11.



afraid you will only be able to see a few points of light, but if you will examine them after the Lecture, you will see them phosphoresce with a most brilliant series of colours—blue, apricot, red, yellowish green, orange, and pale green.

Next to the diamond the ruby is one of the most remarkable stones for phosphorescing. In this tube (Fig. 11) is a collection of ruby pebbles, for the loan of

which I am indebted to my friend Mr. Blogg, of the firm of Blogg and Martin, who placed a small sackful at my disposal. As soon as I turn on the induction spark you will see these rubies shining with a brilliant rich red colour, as if they were glowing hot. Now the ruby is nothing but crystallised alumina with a little colouring-matter, and it became of great interest to ascertain whether the artificial ruby made by M. Feil, of Paris, would glow in the same manner. I had simply to make my wants known to M. Feil, and he immediately sent me a box containing artificial rubies and crystals of alumina of all sizes, and from those I have selected the mass in this tube which I now place under the discharge: they phosphoresce of the same rich red colour as the natural ruby. It scarcely matters what colour the ruby is, to begin with. In this tube of natural rubies there are stones of all colours—the deep red ruby and the pale pink ruby. There are some so pale as to be almost colourless, and some of the highly-prized tint of pigeon's blood; but in the vacuum under the negative discharge they all phosphoresce with about the same colour.

As I have just mentioned, the ruby is crystallised alumina. In a paper published twenty years ago by Ed. Becquerel* I find that he describes the appearance of alumina as glowing with a rich red colour in the phosphoroscope (an instrument by which the duration of phosphorescence in the sunlight can be examined). Here is some chemically pure precipitated alumina which I have prepared in the most careful manner. It has been heated to whiteness, and you see it glows with the rich red colour which is supposed to be characteristic of alumina. The mineral known as corundum is a colourless variety of crystallised alumina. Under the negative discharge in a vacuum, corundum phosphoresces of a rose-pink colour. There is another curious fact in which I think chemists will feel interested. The sapphire is also crystallised alumina, just the same as the ruby. The ruby has a little colouring-matter in it, giving it a red colour; the sapphire has a colouring-matter which gives it a blue colour, whilst corundum is white. I have here in a tube a very fine crystal of sapphire, and, when I pass the discharge over it, it gives alternate bands of red and green. The red we can easily identify with the glow of alumina; but what is the green? If alumina is precipitated and purified as carefully as in the case I have just mentioned, but in a somewhat

* Annales de Chimie et de Physique, 3rd series, vol. lvii., p. 50, 1859.

different manner, it is found to glow with a rich green colour. Here are the two specimens of alumina in tubes, side by side. Chemists would say that there was no difference between one and the other; but I connect them with the induction-coil, and you see that one glows with a bright green colour, whilst the other glows with a rich red colour. Here is a fine specimen of chemically pure alumina, lent me by Messrs. Hopkin and Williams; by ordinary light it is a perfectly white powder. It is just possible that the rich fire of the ruby, which has caused it to be so

FIG. 12.

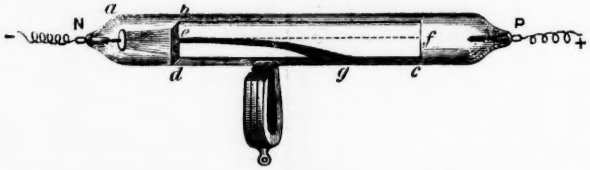
prized, may be due not entirely to the colouring-matter, but to its wonderful power of phosphorescing with a deep red colour, not only under the electric discharge in a vacuum, but whenever exposed to a strong light.

The spectrum of the red light emitted by all these varieties of alumina—the ruby, corundum, or artificially precipitated alumina—is the same as described by Becquerel twenty years ago. There is one intense red line, a little below the fixed line B in the spectrum, having a wavelength of about 6895. There is a continuous spectrum beginning at about B, and a few fainter lines beyond it, but they are so faint in comparison with this red line that they

may be neglected. This line may be called the characteristic line of alumina.

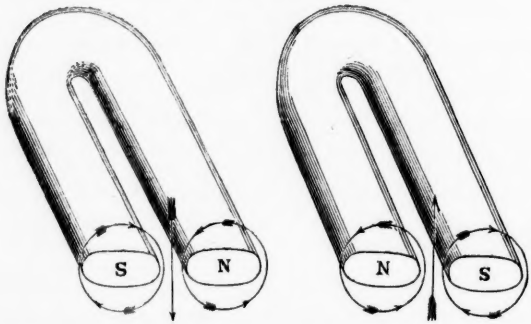
I now pass on to another fact connected with this negative discharge. Here is a tube (Fig. 12) with a negative pole (*a*, *b*) in the form of a hemi-cylinder, similar to the one you have already seen (Fig. 3), but in this case I receive the rays on a phosphorescent screen (*c*, *d*). See how brilliantly the lines of discharge shine out, and how intensely the focal point is illuminated; it lights the whole table. Now I bring a small magnet near, and move it to and fro; the rays obey the magnetic force, and the focus bends one way and the other as the magnet passes it. I can show this magnetic action a little more definitely. Here is a long glass tube (Fig. 13),

Fig. 13.



very highly exhausted, with a negative pole at one end (*a*) and a long phosphorescent screen (*b*, *c*) down the centre of the tube. In front of the negative pole is a plate of mica (*b*, *d*) with a hole (*e*) in it, and the result is that when I turn on the current, a line of phosphorescent light (*e*, *f*) is projected along the

Fig. 14.

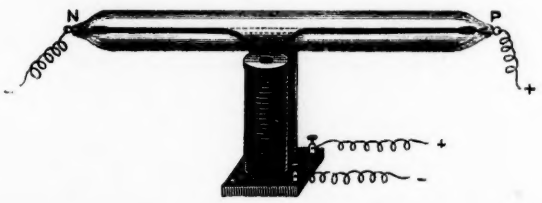


whole length of the tube. I now place beneath the tube a powerful horseshoe magnet: see how the line of light becomes curved under the magnetic influence (*e*, *g*), waving

about like a flexible wand as I move the magnet up and down. The action of the magnet can be understood by reference to this diagram (Fig. 14). The north pole gives the ray of molecules a spiral twist one way, and the south pole twists it the other way; the two poles side by side compel the ray to move in a straight line up or down, along a plane at right angles to the plane of the magnet and a line joining its poles.

Now it is of great interest to ascertain whether the law governing the magnetic deflection of the trajectory of the molecules is the same as has been found to hold good at a lower vacuum. The former experiment was with a very high vacuum. This is a tube with a low vacuum (Fig. 15).

FIG. 15.



On passing the induction spark it passes as a narrow line of violet light joining the two poles. Underneath I have a powerful electro-magnet. I make contact with the magnet, and the line of light dips in the centre towards the magnet. I reverse the poles, and the line is driven up to the top of the tube. Notice the difference between the two phenomena. Here the action is temporary. The dip takes place under the magnetic influence; the line of discharge then rises, and pursues its path to the positive pole. In the high exhaustion, however, after the ray of light had dipped to the magnet it did not recover itself, but continued its path in the altered direction.

During these experiments another property of this molecular discharge has made itself very evident, although I have not yet drawn attention to it The glass gets very warm where the green phosphorescence is strongest. The molecular focus on the tube, which we have just seen (Fig. 12) would be intensely hot, and I have prepared an apparatus by which this heat at the focus can be intensified and rendered visible to all present. This small tube (*a*) (Fig. 16) is furnished with a negative pole in the form of a cup (*b*). The rays will therefore be projected to a focus

in the middle of the tube (Fig. 17, *a*). At the side of the tube is a small electro-magnet, which I can set in

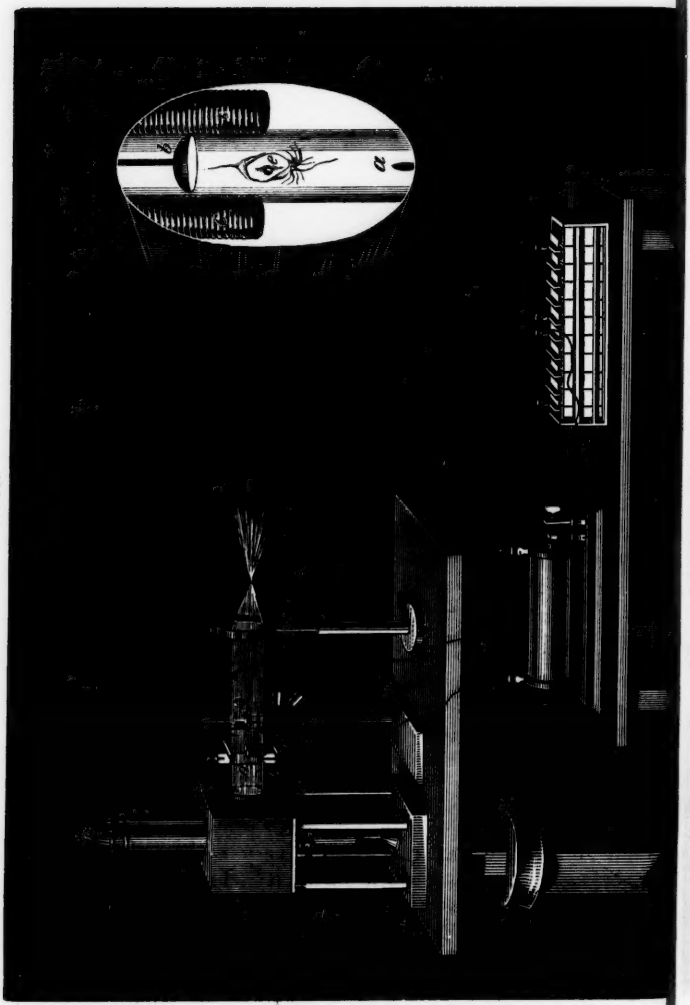
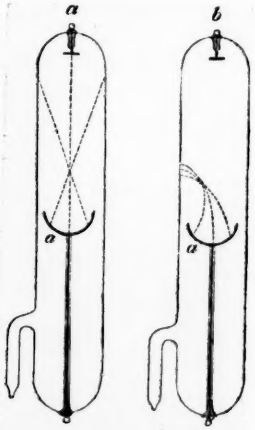


Fig. 16.

action by touching a key, and the focus is then drawn to the side of the glass tube (Fig. 17, *b*). To show the

first action of the heat I have coated the tube with wax. I will put the apparatus in front of the electric lantern (*d*), and throw a magnified image of the tube on the screen. The coil is now at work, and the focus of

FIG. 17.



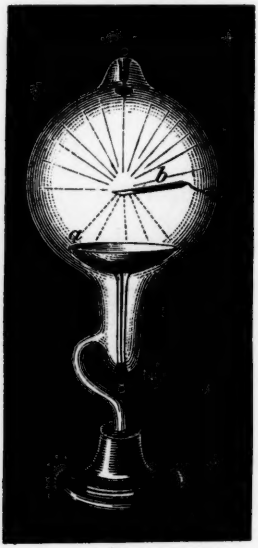
molecular rays is projected along the tube. I turn the magnetism on, and draw the focus on the side of the glass. The first thing you see is a small circular patch melted in the coating of wax. The glass soon begins to disintegrate, and cracks are shooting starwise from the centre of heat. The glass is softening. Now the atmospheric pressure forces it in, and now it melts. A hole (*e*) is perforated in the middle, the air rushes in, and the experiment is at an end.

Instead of drawing the focus to the side of the glass with a magnet, I will take another tube (Fig. 18), and allow the focus from the cup-shaped negative pole (*a*) to play on a piece of platinum wire (*b*) which is supported in the centre of the bulb. The platinum wire not only gets white-hot, but you can see sparks coming from it on all sides, showing that it is actually melting.

Here is another tube, but instead of platinum I have put in the focus that beautiful alloy of platinum and iridium which Mr. Matthey has brought to such perfection, and I think that I shall succeed in even melting that. I first turn on the induction-coil slightly, so as not to bring out its full power. The focus is now playing on the iridio-platinum, raising it to a white-heat. I bring a small magnet near,

and you see I can deflect the focus of heat just as I did the luminous focus in the other tube. By shifting the magnet I can drive the focus up and down, or draw it completely away from the metal, and render it non-luminous.

FIG. 18.

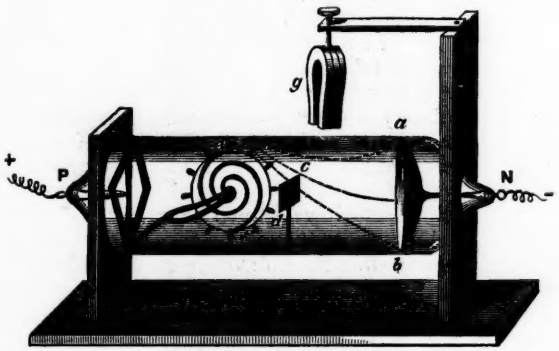


I withdraw the magnet, and let the molecules have full play again; the metal is now white-hot. I increase the intensity of the spark. The metal glows with almost insupportable brilliancy, and at last melts.

There is still another property of this molecular discharge, and it is this:—You have seen that the molecules are driven violently from the negative pole. If I place something in front of these molecules, they show the force of impact by the heat which is produced. Can I make this mechanical action evident in a more direct way? Nothing is simpler. I have only to put some easily moving object in the line of discharge in order to get a powerful mechanical action. Mr. Gimingham, with great skill, has constructed a piece of apparatus which I will presently put in the electric lantern, so that all will be able to see its action. But first I will explain the construction by means of this diagram (Fig. 19). The negative pole (*a*, *b*) is in the form of a

very shallow cup. In front of the cup is a mica screen (*c*, *d*), wide enough to intercept nearly all the molecular rays coming from the negative pole. Behind this screen is a mica wheel (*e*, *f*) with a series of vanes, making a sort of paddle-wheel of it. So arranged, the molecular stream from the pole *a b* will nearly all be cut off from the wheel,

FIG. 19.



and what escapes over and under the screen will hit the vanes equally, and will not produce any movement. I now put a magnet, *g*, over the tube, so as to deflect the stream over or under the obstacle *c d*, and the result will be rapid motion in one or the other direction, according to the way the magnet is turned. I now throw the image of the apparatus on the screen. The spiral lines painted on the wheel show which way it turns. I arrange the magnet to draw the molecular stream so as to beat against the upper vanes, and the wheel revolves rapidly, as if it were an over-shot water-wheel. I now turn the magnet so as to drive the molecular stream underneath ; the wheel slackens speed, stops, and then begins to rotate the other way, as if it were an under-shot water-wheel. This can be repeated as often as I like to reverse the position of the magnet, the change of rotation of the wheel showing immediately the way the molecular stream is deflected.

This experiment illustrates the last of the phenomena which time allows me to bring before you, attending the passage of the induction spark through a highly exhausted atmosphere. It will now be naturally asked, What have we learned from the phenomena described and exhibited, and from the explanations that have been

proposed? We find in these phenomena confirmation of the modern views of matter and energy. The facts elicited are in harmony with the theory that matter is not continuous but composed of a prodigious number of minute particles, not in mutual contact. The facts also are in full accordance with the kinetic theory of gases—to which I have already referred—and with the conception of heat as a particular kind of energy, expressing itself as a rapid vibratory motion of the particles of matter. This alone would be a lesson of no small value. In Science, every law, every generalisation, however well established, must constantly be submitted to the ordeal of a comparison with newly-discovered phenomena; and a theory may be pronounced triumphant when it is found to harmonise with and to account for facts which when it was propounded were still unrecognised or unexplained.

But the experiments have shown us more than this: we have been enabled to contemplate matter in a condition hitherto unknown,—in a fourth state,—as far removed from that of gas as gas is from liquid, where the well-known properties of gases and elastic fluids almost disappear, whilst in their stead are revealed attributes previously masked and unsuspected. In this ultra-gaseous state of matter phenomena are perceived which in the mere gaseous condition are as impossible as in liquids or solids.

I admit that between the gaseous and the ultra-gaseous state there can be traced no sharp boundary; the one merges imperceptibly into the other. It is true also that we cannot see or handle matter in this novel phase. Nor can human or any other kind of organic life conceivable to us penetrate into regions where such ultra-gaseous matter may be supposed to exist. Nevertheless, we are able to observe it and experiment on it, legitimately arguing from the seen to the unseen.

Of the practical applications that may arise out of these researches, it would be now premature to speak. It is rarely given to the discoverer of new facts and new laws to witness their immediate utilisation. The ancients showed a perhaps unconscious sagacity when they selected the olive, one of the slowest growing trees, as the symbol of Minerva, the goddess of Arts and Industry. Nevertheless, I hold that all careful honest research will ultimately even though in an indirect manner draw after it, as Bacon said, "whole troops of practical applications."

NOTICES OF BOOKS.

Transactions and Proceedings of the Royal Society of Victoria. Vols. xiii. and xiv. Melbourne: Mason, Firth, and McCutcheon. London: Williams and Norgate.

We cannot congratulate the Royal Society of Victoria on the subjects of the papers printed in the thirteenth volume of their "Transactions." More than half the volume is taken up with a treatise on practical geodesy, and of the remaining memoirs there is not one which might not quite as easily have been written in London, Paris, or Berlin. What the learned world tacitly expects from such societies is that they shall prominently, and before all things, busy themselves with the rich crop of unrecorded facts and phenomena which surrounds them, waiting, so to speak, for recognition. The geology, the palæontology, botany, zoology, and ethnology of their own region constitute the sphere in which they can render the greatest services to Science and win for themselves the highest honour.

Vol. xiv. contains four noteworthy papers:—"Notes on the Coast-line of the Western District, and Proofs of the Uniform Condition of Meteorological Phenomena over Long Periods of Time," by Mr. T. E. Rawlinson; on some "New Marine Mollusca," by the Rev. J. E. Tennison-Woods—a most able and persevering scientific worker; "Extracts from a Diary in Japan," by F. C. Christy; and "History of Palæozoic Actinology in Australia," by R. Etheridge, jun. The last-mentioned memoir is a summary of what has been already discovered concerning the fossil corals of Australia. Mr. Christy's diary teems with interesting facts concerning the climate, the vegetation, agriculture, and horticulture, the architecture, religion, government, domestic economy, mining, and natural history of these wonderful islands. The author remarks that in Japan eight adults live from the produce of one acre, and keep it in good condition with their excreta, whilst in England the excreta from 800 to 1200 persons are used per acre without profitable result. The fauna of Japan agrees wonderfully closely with that of Europe. Mr. Christy gives a list—too long for insertion here—of butterflies, moths, and bees common to Japan and England, and remarks:—"In referring to the very many species identical with those of England it is remarkable, because Japan consists of a series of islands so very distant and isolated from England, and goes far to disprove Darwin's theory that the farther species are from species—that is, the more they are diffused by distance—the more they must differ, having to struggle for existence over

so great a space." It must, however, be remembered that the isolation between Britain and Japan is less in reality than in seeming. Both are merely outlying portions of one and the same zoological region with which they were at one time actually connected. Most of the species enumerated by Mr. Christy are traceable across the European and Asiatic continents.

Victorian Year-Book for 1877-8. By H. H. HAYTER, Government Statist of Victoria. Melbourne: J. Ferries and G. Robertson. London: G. Robertson.

FROM among the valuable matter to be found in it we extract the following account of the appliances for scientific education existing in the colony of Victoria:—There are Schools of Mines both at Ballarat and Sandhurst. At the former there are classes for different branches of mathematics, for engineering, surveying both above and below ground, chemistry, metallurgy and assaying, telegraphy, and the French and German languages. The chemical laboratory contains twenty work-tables for students, and in the metallurgical laboratory there are twelve reducing furnaces. During 1877 the number of students in the January, April, July, and October terms respectively was 48, 58, 79, and 60. The Museum of the Institution contains 1594 mineralogical and geological specimens, besides models, but—like the library of three hundred bound books—is obviously still in its infancy. The buildings of the Melbourne Public Library have cost £111,604, and are still unfinished. The total number of volumes at the end of 1877 was 101,276.

The Industrial and Technological Museum contains 1100 publications, 23,725 specimens, and 112 drawings. Class lectures are given here on chemistry, mining, and telegraphy, the last-mentioned subject attracting as many pupils as the two former conjointly.

The so-called National Museum occupies a building on the grounds of Melbourne University. It comprises specimens of minerals, stuffed animals and birds, insects, "and other objects of curiosity,"—an expression which savours of the pre-scientific ages when biological collections were not understood to be means for study.

The account of Melbourne University throws no light on the all-important question whether it is preparing students for actual research or merely turning out examinees.

Journal of Proceedings of the Royal Society of New South Wales for 1877. Vol. xi. Sydney: Richards. London: Trübner and Co.

We may fairly congratulate the Royal Society of New South Wales both on the quantity and quality of the work it is doing. Of the nineteen papers herein contained all save three deal—and deal usefully—with local facts. We must more particularly notice an account of *Dromornis Australis*, a newly-discovered extinct gigantic bird of Australia. The species was founded on a femur discovered at Peak Downs, in Queensland, which the Rev. W. B. Clarke and M. G. Krefft at first referred to the genus *Dinornis*, and which consequently seemed a proof of a whilom land-connection between New Zealand and Australia. Prof. Owen, however, pointed out that this bone agrees in its essential characters more with the emu than the moa, and that it indicates the former existence of a bird nearly of the stature of the ostrich, but with relatively shorter and stronger hind limbs. Hence it appears that Australia, like all other tracts of land in the southern hemisphere, whether insular or continental, was at one time inhabited by gigantic "flightless" birds.

The Rev. W. B. Clarke communicates another paper on a new fossil extinct kangaroo (*Sthenurus minor*), part of the skull of which was found in the shaft of a gold-lead in Phillip County, New South Wales. He expresses a fear that in the indiscriminate slaughter of marsupials now in progress some species not yet recognised may perish unnoticed.

A paper on the "Forest Vegetation of Central and Northern New England" may at first sight be open to a misunderstanding. This name has, as if for the very purpose of creating confusion, been given to a district in Australia. The author, Mr. W. Christy, gives an account of a carnivorous plant *Drosera peltata*, —the "bottle-weed" of the squatters,—which is accused of causing disease in sheep, There is also a description of twenty-one species of *Eucalyptus* growing in this region.

Dr. W. J. Barkas communicates memoirs on the "Sphenoid, Cranial Bones, Operculum, and supposed Ear Bones of *Ctenodus*," and on a "Dental Peculiarity of the Lepidosteidæ."

Natural History of Victoria. Prodromus of the Zoology of Victoria, or Figures and Descriptions of the Living Species of all Classes of the Victorian Indigenous Animals. Decade I. By Frederick McCoy. Melbourne: J. Ferries and G. Robertson. London: Trübner and Co.

We have here the beginning of what promises to be a most valuable work, creditable alike to its author and the Victorian

government. The animal species are carefully figured in their natural colours, and the descriptions of their characteristics, general structure, habits, and locality are full and apparently accurate. The first three plates are devoted to three of the most dangerous snakes of the province—the black snake (*Pseudechys porphyriacus*), the copper-head (*Hoplocephalus superbus*), and the tiger-snake (*H. curtus*). Concerning these species there prevails some confusion of nomenclature, which tends to render accounts of the effect of their bite and of the value of antidotes untrustworthy. Thus in Tasmania the tiger-snake is known as "carpet-snake," a name given on the mainland to an innocent species. In the same island the black snake has received the name of "diamond-snake," which properly belongs to a harmless species of New South Wales. As regards the bites of these Australian "death-snakes," ammonia taken internally or injected into a vein has in some cases at least proved successful, whilst for the bite of the Indian cobra it appears to be invariably useless. This important distinction suggests some questions weighty at once from a speculative and from a practical point of view. Do the poisons of different serpents differ merely in concentration, or are they chemically distinct, requiring consequently a distinct line of treatment? If so, do we find identity, or at least close relation, among the venoms derived from snakes of the same family, just as in the vegetable kingdom we find allied groups of alkaloids pervading certain families, as in the Cinchonaceæ, the Strychnaceæ, &c. The chemists, and no less the biologists, of Australia have here a most enviable field for research laid before them.

Plate VII. is devoted to *Megascolides Australis*, the giant earthworm, which, when fully extended, is about 6 feet long. The remaining three plates represent Lepidopterous insects. One of these, *Agarista glycine*, a day-flying moth of the curious family Alraniidæ, is remarkable for the change of habits it has undergone. Its original food was the common weed *Gnaphalium luteo-album*. But since the planting of vineyards it has completely abandoned its former food, and devours the leaves of the vine, occasioning enormous injury. How the female moth could learn that a foreign plant having no structural resemblance to the *Gnaphalium* would yet afford suitable nourishment to her future brood is one of the many "nuces zoologicæ" which our successors may some day crack. Certainly she could not in this case be guided by "hereditary habit." Fowls will not eat them, and the Indian minah—introduced into the colony as a vermin-killer—has developed a taste for grapes instead of devouring the larvæ. *Thyca Harpalyce* and *Aganippe* are butterflies resembling our "whites," but with rich red spots on the under side of the posterior wings. In the former, the angularity of the tip of the upper wing varies in different individuals of the same brood.

We trust that other of our colonial governments will follow the example set at Melbourne.

Tenth Annual Report of the United States Geological and Geographical Survey of the Territories. Embracing Colorado and parts of Adjacent Territories; being a Report of Progress of the Exploration for the Year 1876. By F. V. HAYDEN. Washington: Government Printing-Office.

THIS bulky and profusely illustrated volume embraces the geology of the district, its mineralogy, topography, archæology, ethnology, and, lastly, its palæontology. In all these departments good work has been done, and important results are not wanting. In a mine on Mount McClellan, near George Town, solidly frozen masses were found at the depth of more than 200 feet from the surface. The walls and roof of the workings are lined with ice-crystals. The cause of this remarkable phenomenon is not known, though it is surmised that chemical changes are in progress in the surrounding rocks which effect a fall of temperature. What these processes may be remains to be discovered. The deposits of tellurets and of uraniferous ores in Colorado are remarkably rich, and splendid specimens have been obtained.

Mr. A. S. Packard, jun., contributes a report on several injurious insects, especially those attacking the cranberry. If the cranberry of America is identical with that of North-eastern Europe we should regard its extinction with much equanimity, and we can assure all who admire this fruit that they can easily reproduce its flavour by adding a stale decoction of nut-galls to the common red currant. An instance is given of a beetle (*Monohammus titillator*) which had remained alive in wood for at least fifteen years.

CORRESPONDENCE.

IMPERFECTIONS OF NATURE.

To the Editor of the Monthly Journal of Science.

Sir,—The writer of the article "Is Nature Perfect?"—which appeared in your number for April—might have usefully controverted a mistaken notion as to the difference between natural objects and works of art. We are often told that the latter, however beautiful they may seem to the naked eye, on examination with a high magnifying power betray a multitude of flaws and defects, whilst the former will bear the most rigid microscopic scrutiny. This is by no means universally the case, not a few natural products displaying a want of symmetry and finish when viewed with a strong lens. To our unaided sight the antennæ of a male gnat appear like beautiful plumes, but if magnified they remind us irresistibly of a bottle-brush. Or take the finger-tip of the most delicate lady; to the eye it seems beautifully smooth and even, whilst with a lens we perceive its surface to be rough, furrowed, and rugged. These cases are by no means singular.—I am, &c.,

Plain Facts.

SOUND AS A NUISANCE.

To the Editor of the Monthly Journal of Science.

Sir,—I fully agree with the writer of an article in your April number, that man's inability to shut out sound at will is a misfortune. But is it not possible that the vibration set up by powerful sounds might have a disturbing action upon our nerves even were we unable to hear? Thus the sensations akin to sea-sickness which some persons, myself included, experience if saluted by the deep notes of a large organ, seem to depend more on the undulations of the floor than upon the sound as such.—I am, &c.,

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PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY, *May* 8.—"On the Sensitive State of Electrical Discharges through Rarefied Gases," by William Spottiswoode, P.R.S., and S. Fletcher Moulton. It has frequently been remarked that the luminous column produced by electric discharges in vacuum tubes sometimes displays great sensitiveness on the approach of the finger, or other conductor, to the tube. This is notably the case when with an induction-coil a very rapid break is used, or when with any constant source of electricity an air-spark is interposed in the circuit leading to the tube. The striking character of the phenomena, and the opportunity which they showed for affecting the discharge from the outside during its passage, led the authors of this paper to consider that a special examination of this sensitive state would be desirable. If a conductor be made to approach a tube conveying a sensitive discharge, due to an air-spark in the positive branch of the circuit, a series of effects is produced, of which the feeblest and the strongest are the most pronounced. In the first case, the luminous column is repelled by the conductor; in the second, it is broken into two parts which stretch out in two tongues towards the point on the tube nearest the conductor, while a negative halo appears between them. These effects are proved to be due to the inductive action of the conductor, or more particularly to re-distributions of electricity in it, co-periodic with the air-spark, and not to any permanent charge. Instead, however, of connecting a point on the tube with a large conductor or with earth, it may be connected with one or other terminal of the tube. And a further study of the subject shows that all the phenomena due to action from without may be produced by means of one or other of these connexions. The effects described need not be confined to a single patch or ring of conducting material placed upon the tube; but they may be produced many times over in the same tube by a series of rings arranged at suitable distances. By this means the column may be broken into a series of sections, all terminating with well-defined configurations towards the negative end, and having greater or less length, according to the position of the rings. The authors give evidence, derived mainly from the revolving mirror, and from the discharges of a partially charged Leyden jar, for the following conclusion:—That the passage of the discharge occupies a time sufficiently short in comparison with the interval between the discharges to prevent any interference between successive pulses. Certain experiments are then described which indicate that the discharge is effected, under ordinary circumstances, by the passage through

the tube from the air-spark terminal of free electricity, of the same name as the electricity at that terminal. The authors are further led to the conclusion that the discharges at the two terminals of a tube are in the main independent, and that they are each determined primarily by the conditions at their own terminal, and only in a secondary degree by those at the opposite terminal. Having traced the relation between the two parts of the discharge, and having found means for controlling their range and influence, the authors were led to enquire whether there be any experimental evidence of the state of the tube during the occurrence of the discharge. The phenomena appear to require for their interpretation that, in front of the pulse coming from the (positive) air-spark terminal, there is, during the interval between the pulses, a rising negative potential: this is entirely swept out by the pulse as it advances along the tube; after which the process is repeated. The condition of things behind the pulse is more difficult to determine; but an experiment with the telephone gives reason to think that parts of the tube nearer to the non-air-spark end are in a condition to demand relief, before those nearer to the air-spark terminal have ceased to require it. And on this account the discharge may, perhaps, be more nearly represented by a lazy tongs than by a bullet. The marked similarities in the phenomena, and the predisposing circumstances of striation or non-striation, as well as in the terminal peculiarities of the two kinds of discharge, point strongly to the conclusions that all vacuum discharges are disruptive; and that sensitive differ from non-sensitive discharges mainly in the scale of the discontinuity due to the disruptiveness, causing a difference between the two classes of phenomena analogous to that between impulsive and continuous forces in dynamics.

"On the Relation between the Diurnal Range of Magnetic Declination and Horizontal Force, as observed at the Royal Observatory, Greenwich, during the years 1841 to 1877, and the Period of Solar Spot Frequency," by William Ellis, F.R.A.S. In this paper the author draws attention to the long series of magnetical observations which have been made at the Royal Observatory, under the direction of Sir George B. Airy, K.C.B., Astronomer Royal. Commencing in the year 1841, the observations for a few years consisted of eye-readings of the various instruments, made every two hours; since the year 1848 the motions of the magnets have been registered by photography, according to a plan arranged by Mr. Charles Brooke. Attention is briefly drawn to the question of magnetic variations, and to the circumstance that examination of the Greenwich records shows that, in addition to the ordinary diurnal and annual changes, there appears to exist, in the magnetic diurnal ranges, an inequality of marked character and of longer period, resembling in its features the well-established eleven-year sun-spot period. The following are the general conclusions supposed to be derived from the whole inquiry:—

1. That the diurnal ranges of the magnetic elements of declination and horizontal force are subject to a periodical variation, the duration of which is equal to that of the known eleven-year sun-spot period.
2. That the epochs of minimum and maximum of magnetic and sun-spot effect are nearly coincident; the magnetic epochs, on the whole, occurring somewhat later than the corresponding sun-spot epochs. The variations of duration of different periods appear to be similar for both phenomena.
3. That the occasional more sudden outbursts of magnetic and sun-spot energy, extending sometimes over periods of several months, appear to occur nearly simultaneously and progress collaterally.
4. That it seems probable that the annual inequalities of magnetic diurnal range are subject also to periodical variation, being increased at the time of a sun-spot maximum, when the mean diurnal range is increased, and diminished at the time of a sun-spot minimum, when the mean diurnal range is diminished.

Conclusions Nos. 1, 2, and 3 appear to be sufficiently certain, but the evidence in favour of No. 4 is not so decisive.

"On the Results of the Magnetical Observations made by the Officers of the Arctic Expedition, 1875-76," by Staff-Commander E. W. Creak, R.N., attached to the Admiralty Compass Department. This narrative and results form the sequel to the "Memorandum on Terrestrial Magnetism," prepared by Prof. J. C. Adams, M.A., F.R.S., and Capt. F. J. Evans, R.N., F.R.S., published in the "Manual and Instructions for the Arctic Expedition," 1875," suggested by the Arctic Committee of the Royal Society. The *Alert* and *Discovery* left Portsmouth on May 29th, 1875. On September 1st, 1875, the *Alert* reached her winter quarters at Floeberg Beach, lat. 82° 27′ N., long. 61° 22′ W. The magnetic observatory, constructed entirely of snow, was situated at a distance of 200 yards from the ship. It was divided into three distinct houses 27 feet apart, and in these the horizontal force magnetometer, Barrow's dip-circle, and the differential declination magnetometer were secured to snow pedestals. As no stove was used the range of the thermometer registered was from $-10°$ to $+4°$. The *Discovery* took up winter quarters at Discovery Bay, 53 miles S.W. of the *Alert*, in lat. 81° 44′ N., long. 65° 3′ W., on August 26th, 1875. The magnetic observatory house was constructed of wood, and stood on the shore 197 yards from the ship, and the pedestals formed of the ship's binnacles sunk into the ground were found to be very firm. For the differential declination magnetometer an ice house was built on the ice-floe 90 yards from the ship, the magnetometer being frozen on to a pedestal of ice. One of the chief subjects of interest in the magnetical results of the observations

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at the winter-quarters' observatories is that of the diurnal variation or inequality of the declination, and frequent magnetic disturbances, the latter especially, as the ships wintered in a region remarkable—as is proved—for an absence of brilliant auroras, and in which no connexion was observed between the appearances of that phenomenon and movements of the declinometer magnet. Hourly observations were made with the differential declination magnetometers, and on all occasions of great disturbance special observations at frequent intervals. The greatest range of the declination was observed on February 19th, 1876, about the same hours, at Floeberg Beach and Discovery Bay, reaching 5° 9·4′ and 5° 47·9′ respectively. The smallest range was observed on January 12th, when only 0° 4′ was recorded at the first-named station, and 0° 6·9′ at the last. On an average about every eighth day the higher values of the daily range were attained, and comparing the highest with the lowest scale-reading during the whole period, it shows that the magnet moved over 8° of arc. For computing the mean hourly values of the disturbances of the declination, the formula used by Sir J. H. Lefroy, in the published volume of his "Magnetical and Meteorological Observations at Lake Athabasca," &c., was adopted. From the values of the mean hourly disturbance, without regard to sign, it is found that the disturbing force never ceases, and that in the mean monthly values it *decreases* as the winter solstice is approached, and *increases* rapidly towards the equinox. Taking the difference between the mean easterly and mean westerly disturbances, it is found that the easterly disturbance is both moderate in amount and monthly change when compared with the westerly. The comparison of the disturbances at Kew and the two winter-quarters' observatories of the Arctic Expedition, 1875-76, appear to confirm M. Gauss's conclusion, that "the synchronous disturbances of the same element not only differ widely in amount, but occasionally appear to be even *reversed* in direction." The appearances of auroras and the synchronous movements of the declinometer magnet were subjects of special observation during the stay of the *Alert* and *Discovery* at their winter quarters. On all occasions they were observed to be faint, with none of those brilliant manifestations which are described by our own officers as seen at Point Barrow, and by the Austro-Hungarian Expedition in Franz Josef Land, where the magnetical instruments were so sensibly disturbed. These phenomena were not observed either in the *Alert* or *Discovery*,—especially no connexion between magnetical disturbances and the appearances of auroras could be traced. The following description of the aurora observed on November 21st, 1875, is given by Commander Markham and Lieut. Giffard in their abstract of observations at Floeberg Beach:—"Between 10 and 11 p.m. bright broad streamers of the aurora appeared 10° or 15° above the north horizon, stretching through the zenith, and terminating in an irregular curve about 25° above the south horizon, bearing S.S.W.

During the aurora's greatest brilliancy the magnet was observed during five minutes to be undisturbed." The aurora was visible on forty-nine days between October 22nd, 1875, and February 27th, 1876. The observations from which the foregoing magnetical results have been obtained were made by Commander (now Captain) A. H. Markham and Lieut. G. A. Giffard of the *Alert*, and Lieuts. R. H. Archer and R. B. Fulford, of the *Discovery*.

PHYSICAL SOCIETY, *March* 22, 1879.—Prof. W. G. Adams, President, in the chair.

Capt. Abney, R.E., F.R.S., read a paper "On obtaining Photographic Records of Absorption Spectra." Absorption spectra have hitherto been recorded by the difficult process of hand copying; but the discovery by Capt. Abney of a silver salt sensitive to all rays in different degrees renders the photographic method available. The records thus obtained are photographs of the spectrum of the naked light of the source, and of that of the same light reduced by insertion of the absorbing material in its track, and these are taken parallel, so that the dark absorption lines can be readily compared. Examples of these were thrown on the screen. This method can be used as a new weapon in attacking solar physics, and determining whether or not compound bodies exist in the sun. Absorption spectra to compare with the sun's can be got for compound bodies by burning the matter in question in a flame in front of the slit, and passing a bright light through the flame.

Prof. Guthrie, F.R.S., then read a paper "On the Fracture of Colloids," as illustrated by experiments on the breakage of glass plates, either by pressure or heating at the centre or round the circumference. Circular plates of glass pressed at centre or circumference break in radial lines. However supported, a plate breaks in the same fashion if heated in the same way. If heated in the middle the crack is peak-shaped, like an obelisk on a double pedestal, two cracks forming the outline, with sometimes a third down the middle. The two cracks unite before they reach the edge on one side, and (as afterwards pointed out by Prof. W. G. Adams) the three extremities of the two cracks all meet the edge at right angles to it. The crackage varies with the size and shape of the plates, the flame, and kind of glass; but the type is the same for all. Cracks cross each other. Prof. Guthrie defined a crack as the line where the ratio of cohesion to strain is least, and likened it to the lightning flash.

April 26.—Mr. C. V. Boys gave an account of some experiments made by Dr. Guthrie and himself on the subject of Arago's rotation. The experiments were begun with a view to determine if the drag on a copper disk when a magnet is made to revolve beneath it, or on the magnet if the disk is made to revolve above

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it, could be made use of for determining the velocity of running machinery. They made the magnet revolve, and obtained the angle of deflection of a disk suspended by a torsion thread (the hair-spring of a watch). They found, as Snow Harris and others found before, that, other things being equal, the drag is directly proportional to the speed, so that if the torsion of the thread could be relied on, and the strength of the magnet did not change, a perfect velocimeter could be constructed. They consider that this method is better than observing the deflection of a magnet over a revolving disk, as in this case they are limited to less than a right angle, and changes in the absolute magnetism of the earth would affect the results. They also determined the effect of change of distance, thickness, diameter, and nature of the disk, &c., their results agreeing with those of former experimenters. They observed that the effect of concentric circular cuts was far greater than that of even many radial cuts; and that when radial sectors were entirely separated from each other the effect was much less than when these were united at the centre. They then experimented on liquids by suspending a sphere or cylinder of the liquid between the poles of a revolving electro-magnet, and succeeded in getting a decided and measurable effect. The importance of this is very great, for they have thus a means of determining the conductivity of liquid electrolytes by currents induced in the liquid without the use of electrodes and without polarisation.

Dr. Guthrie stated that as the push on the liquid is directly proportional to the current quantity, they hope to measure the conductivities of liquids, and connect these to the conductivity of solids through the intervention of mercury.

Prof. Sylvanus Thompson then communicated five laboratory notes from University College, Bristol. The first related to the source of sound in the Bell telephone receiver. Two theories are now being discussed as to this effect: the molar theory regards the motion of the diaphragm in mass as the source of sound; the molecular theory finds it in the molecular motions of the magnetic core of the instrument. Prof. Thompson applied his method of getting magnetic curves with iron filings dusted on gummed glass to this problem. He found that when no currents passed in the telephone the magnetic lines springing from the pole of the magnet are gathered together on the diaphragm opposite, over a central region, which is magnetised lamellarly, or like a magnetic shell. The rim of the plate beyond this region is, however, magnetised radially, and between these two zones there is a neutral circle. It was remarkable, too, that the lines of force touching the plate were bent back around the circle, forming a kind of valley. When the current passed in the coil in a direction so as to reinforce the magnetism, the lines are gathered more closely on the central region of the plate. If the current diminishes the magnetism the lines are, on the other

hand, repelled from the plate. The neutral line is also altered. In the first case it shrinks in size, in the second it expands. A small thick disk is wholly magnetised lamellarly; a disk entirely magnetised radially becomes slightly conical in shape. In the actual telephone the disk is flat at the middle and conical at the edges. As the neutral ring shifts, the diaphragm will assume new nodal lines. Dr. Thompson concludes that the molecular theory is not, therefore, necessary to account for the speech of the telephone, although it may assist. As confirming this view, he found that with iron rings round a cardboard diaphragm and an iron centre-piece the enunciation was good, though the *timbre* was altered; whereas with radial pieces of iron on the cardboard the *timbre* was good, but the enunciation bad.

Dr. Thompson next wrote on a saw blade with a magnet, and dusted iron filings on it, which arranged themselves so as to trace the writing. This is usually shown on a steel plate, but a saw retains the virtue for six or eight months. A modification of this experiment due to himself consisted in writing on the blade with one pole of a powerful battery, the other pole being connected to the end of the blade.

The third "note" recommended the use of fine steel fibres, got by breaking iron gauze of thirty-two meshes to the inch, instead of iron filings for exhibiting magnetic lines. The fourth note showed that the lines of force got by filings fixed on cards are magnetic, that of a magnet acting as a magnet. The fifth note explained that solid magnetic "figures" could be got by coating iron filings in shellac to make them light, and floating them in water, or by mixing filings in a soft paste of plaster-of-paris, which could be cut into sections on hardening.

May 10.—Mr. Wollaston explained the construction of Gower's improved form of Bell's speaking telephone. The older form, made of wood or ebonite, is open to the objection that it has a very weak voice, soon gets out of adjustment from changes of temperature, and requires a twisted hand wire, which is liable to break. Gower's form has a comparatively loud utterance, is constant, and does not require to be held in the hand, but may be laid on a table or hung on a wall, a speaking-tube leading from it to the operator's ear or mouth. The "call for attracting attention is also within the Gower telephone itself; whereas in the hand telephone it is an auxiliary apparatus. Every organ of the old telephone has been modified to form the Gower. The magnet in the Gower is of a horse-shoe form, very powerful, the two poles being brought very close together, and each pole is mounted with a small coil of fine wire. The diaphragm is much thicker and larger than the Bell diaphragm. The case is of brass, to expand equably, and a speaking-tube is fitted to the front of the diaphragm. The call consists of a musical reed attached to the diaphragm, so as to be opposite a small slit in

the latter. To sound the call it is only necessary to send a sharp puff of wind up the speaking-tube, and the reed gives out a note which is heard throughout a room at the distant end. Speaking and cornet music was transmitted to the instrument exhibited, between the third storey over the hall and the meeting. It was very distinct and audible several feet from the receiver. Speaking done some 30 feet from the transmitter was also sent. Conversation was likewise carried on while considerable noise was being made in the room.

Prof. W. F. Barrett then gave an account of some attempts which he had made to overcome the induction clamour on telephones caused by the ordinary telegraph currents on neighbouring wires. He had tried recently the Bell telephone on a line from Dublin to Armagh, 95 miles long, but the induction noises completely stifled the speaking, whereas the Edison transmitter gave good results. The clamour could be got rid of either by neutralising the induction currents or by eliminating the noises from the speech.

Mr. Wollaston pointed out that a perfect cure for induction on underground wires consisted in twisting the going and returning wire of the telephone circuit round each other.

Mr. Wilson then read a paper "On the Divisibility of the Electric Light by Incandescence." The question of divisibility resolves itself into our being able to divide a single incandescent source into a number of smaller ones giving the same total illumination. The author concludes that this can be done by arranging the subdivided sources in "multiple arc," or parallel circuits, provided the total mass, length, and sectional area of the united sources be the same as in the original single source. The objection that increased radiation from the various sources would diminish the first total of light and heat can be met by making the smaller wires still smaller than is theoretically required so as to generate more heat. The author regards the "voltaic arc" as probably falling under the same law, the mass, however, being smaller in this case.

Dr. Coffin then exhibited a Trouvé Polyscope, which consists of a small hand incandescent platinum wire electric light, designed for illuminating the more inaccessible cavities of the body in surgical examinations. The current is supplied by a Planté secondary battery, and the light is half enclosed in a small silver reflector, fitted with a convenient handle. The apparatus is portable. Dr. Coffin found that it was open to several objections, which he has remedied. Dr. Coffin has superseded the secondary battery by a Leclanché battery of eight elements, made by Messrs. Coxeter and Sons, in which the carbon pole is replaced by a copper plate faced with platinum, and no porous diaphragm is employed. This gives a constant light for hours.

NOTES.

Biology.

Mr. E. Gittins, of Tivoli, Queensland, in a letter to the Editor, communicates some interesting facts concerning ants. He writes:—"If meat shows the least possible tendency to decompose—and it will do so in the course of twelve hours in summer—the ants will find it, though suspended by a wire or string from the house-top or the top of a tent. The ant perceives decomposing animal matter at a long distance, and does not go exploring for such matter, but goes straight to it from the ant-hill. A snake killed in the Bush is generally placed on the branch of a tree, so as to be seen by travellers, and as soon as decomposition sets in the ants find it, and the flesh is soon carried off to the ant-hill; even their own comrades, when killed, are carried off to the underground cells. They never stay to feed, but they take up the booty and off they go." The writer then describes a number of experiments, showing that portions of meat placed near ant-roads were overlooked till putrefaction set in, and were then eagerly carried off. He remarks that "ants that feed on saccharine matter are as difficult to keep off as the carrion-feeders; they smell the sugar, and endeavour to get at it wherever it may be placed. The largest kind of sugar-ants will feed until the cold air of night comes on, and then fall into a stupor and there remain during the day." We should feel much obliged if our correspondent would determine the two following points:—Whether his meat ants prefer tainted meat to fresh when both are placed equally near, as, *e.g.*, close to one of their roads; and whether they will attack animal matter in an advanced stage of decomposition? It certainly seems that they occupy a more prominent place among "Nature's Scavengers" than has been hitherto supposed.

According to M. Max Cornu, a new malady is attacking plants belonging to the order Rubiaceæ preserved in hot-houses in France. An *Anguillula* deposits its eggs in the roots, which swell and decay, while the plant speedily perishes. The depredator is closely allied to the species which has occasioned so much havoc in the coffee-plantations of Brazil.

M. G. Bonnier has laid before the Academy of Sciences an anatomical and physiological study of the nectaries of plants. He criticises the views of Messrs. Darwin, Müller, Lubbock, &c., and in opposition to their views contends that the dimensions of the corolla, the development of colour in the flowers, of perfumes, spots, and stripes, are not correlated to the formation of

nectar, and are independent of the visits of insects. He maintains that, in nectariferous dicœcious plants, insects do not visit the male flowers first and the female flowers afterwards, the greater visibility of the former being indifferent. One and the same flower may be visited in various manners by the same insect. The form of a flower may be altered without sensibly modifying the visit of insects. Insects may very often collect the nectar of flowers without effecting their fecundation; the insect-guests of one and the same flower differ according to the quantity of nectar which it produces, and, as this quantity varies with altitude and latitude, the insect-guests of one and the same species differ in different countries. We cannot conclude, from facts observed, that the colour of flowers, the shape of the corollas, &c., are arranged for the exclusion of insects not adapted for cross-fertilisation. In short, there is no reason for admitting a reciprocal adaptation between insects and flowers. There are, further, nectaries without external nectar and all intermediate stages. There are also numerous nectariferous tissues unconnected with flowers. The nectariferous tissues, floral or extra-floral, whether they emit a liquid or not, are special nutritive reserves, in direct relation with the life of the plant. [Without seeking to anticipate the discussion to which this paper must give rise, we cannot avoid pointing out that the facts detailed by M. Bonnier are by no means incompatible with the theory of a mutual adaptation between flowers and insects.]

A writer in "Science Gossip" calls attention to the peculiar position of the mouth in sharks as very difficult of explanation on the Natural Selection hypothesis.

The small annual sum allowed for the purchase of specimens for the zoological department of the British Museum is to be reduced from £1200 to £900.

An anti-vivisection hubbub has sprung up in Germany,, and has now reached a dangerous stage. Unless our Teutonic colleagues are watchful they will some day find research fettered as it is amongst us.

A collection of Lepidoptera from the mouth of the Amur River, exhibited at the February meeting of the Entomological Society, was strikingly European in general character, some of the species being even identical.

M. Lichtenstein has communicated to the Academy of Sciences an account of *Ritsemia pupifera*, a kind of cochineal insect living on the elm, and holding an intermediate position between the Cocci and the Phylloxeræ. In August there appear, on the bark of the elm, small red unisexual lice, with six-jointed antennæ; they evolve a cottony matter, and lay in it not eggs, but pupæ. From these are developed, in the following May, the bisexual individuals, the males of which are apterous, having nine-jointed antennæ and no rostrum. The females, which

appear a few days later, much resemble the autumnal generation, but their antennæ are eight-jointed. This mode of reproduction, anthogenesis, has been hitherto traced among the Phylloxeræ and all the Pemphigians. We now recognise it among the Coccidæ.

M. Ch. Richet has studied the mode of contraction of the muscles of the crayfish. He remarks that in the muscles of the tail the shock of contraction is very short, whilst in the muscle of the claws it is much longer than in the muscles of vertebrate animals, excepting the cardiac muscle. The claws of the crayfish, if separated from the body and protected from heat and evaporation, preserve their contractility for more than four days.

Dr. L. Frédéricq, in an inaugural dissertation, shows that the plasma of the blood is made up of fibrinogen, coagulating at 56°; paraglobulin, coagulating at 75°; and serin, at 65°. He finds that the coagulation of blood is a phenomenon in which gases do not intervene in any manner. The carbonic acid is shared between the globules and the plasma (or serum) in the same manner both in circulating blood and in coagulated blood. The red globules are capable of absorbing a notable quantity of carbonic acid.

The "Colonies and India" gives a description of a species of *Coccus* found in Yucatan, and known locally as the niin or neen. It feeds on the mongo, and secretes a large quantity of semi-fluid fat used for various purposes by the natives. If strongly heated a portion evaporates, leaving a plastic waxy matter capable of serving as a varnish. If burnt, it changes to a thick semi-fluid like dissolved caoutchouc, but which solidifies on standing. Numerous applications of these substances are possible.

The editor of the "Scottish Naturalist" recommends, for special observation this season, the possible effects of the abnormal winter and spring upon birds, insects, molluscs, &c.; what species have suffered most; how the reappearance of migratory and hybernating species may be influenced; and especially the degree of colour-variation, and whether such variation, if it occur, tends to melanochroism or leucochroism. Such observations, he justly considers, will aid in throwing light upon the causes influencing the geographical distribution of species.

Mr. R. Ward records, in the "Standard," the discovery of certain fossil remains in excavations now in progress at Charing Cross. The identified specimens are tusks and molars of an extinct elephant (*E. primigenius ?*), a horn of the Irish elk, and bones and teeth of a gigantic ox (*Bos primigenius*).

According to the "American Naturalist" there is reason to fear that the biological department of the great Survey of the Territories is to be abolished. The admirable work which for many years has been done in this department pleads trumpet-tongued against its discontinuance.

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Benzol, taken internally, reduces the arterial tension by one-half, and thus aproximates in its action to nicotin. The venous tension is at the same time increased, and the action of the heart accelerated. The secretions are modified; glycosuria is produced in guinea-pigs, but rarely in rabbits, and never in dogs. Phenic acid has been in some cases detected in the blood and the urine.

M. J. Rambosson has communicated to the Academy of Sciences ("Comptes Rendus," April 14th) a paper on the propagation of nervous phenomena. He proposes the following law:—"A purely physical movement may be transformed into a physiological movement, and into a psychic or cerebral movement, by transmission to these different media; and reciprocally a psychic movement may be converted into a physiological and into a physical movement by a corresponding transmission, without any alteration in its nature,—that is to say, it reproduces the same phenomena after all these transmissions and transformations on returning into the same medium.

Dr. Broca has received the brain of an individual of the species *Gorilla Savagii*, aged 2½ years. In the fresh state it weighed 416 grms., which is heavier than the specimen sent in 1876 by Dr. Négre, which weighed only 363 grms., and belonged to another species.

At a recent session of the Anthropological Society of Paris a debate took place on the origin of the blonde race of mankind. Some of the speakers considered that the region of Turkestan was their original seat, whilst others—in particular Madame C. Royer—maintained that they had originated in Europe.

MM. Bancel and Husson have communicated to the Academy of Sciences observations on the phosphorescence of the flesh of the lobster. They consider it due to a fermentation in which carbo- and phospho-hydrogens are liberated, and which is destroyed by putrefaction, just as the bacteria of carbuncle are destroyed by the vibriones of putrefaction.

M. L. Collot has discovered the true *Phylloxera vastatrix* upon *Vitis caribæa*, a wild species of vine found in the forests of Panama, far removed from any vineyards or localities where the true vine (*V. vinifera*) is cultivated. This strongly confirms the opinion that the *Phylloxera* is indigenous in America.

Experiments conducted in the laboratory of Prof. Kühn, of Heidelberg, lead to the conclusion that the so-called "visual purple" of the eye is not essential to vision. It is wanting in several animals which we must consider to be possessed of the sense of sight, and in men it is absent in the "yellow spot,"—that part of the retina in which vision is most distinct.

Dr. A. Horwarth, writing in "Pflüger's Archive" (xvii., Heft I. and II.), contends that—in addition to heat, light, oxygen, and nutrition—rest is needful for the production and maintenance of

life. He finds that bacteria are incapable of living in the arteries of animals. Continued motion for twenty four hours hinders the multiplication of *Bacterium termo* and of the *Bacillus* of Cohn, whilst if left in absolute repose they increase rapidly. [This conclusion does not hold good universally; certain low vegetable forms, known familiarly as sewage fungus, seem to flourish best in waters which move swiftly, and are scarcely to be detected in the same waters when perfectly at rest.]

Physics.

From a Report on the Electric Light on the Thames Embankment, which has been submitted to the Metropolitan Board of Works by Sir Joseph Bazalgette and Mr. Keates, we learn that the total cost of twenty lamps per night, of five and a half hours, was about 5·73 pence per lamp per hour. With regard to the value of the light, it is found that with opal shades not less than 59 per cent of the whole light produced was wasted, while with shades made of frosted glass the loss only amounted to 29·9 per cent. Comparing the light produced from gas with the electric light, it is shown that the cost of gas equivalent in power to the electric light is not much over one-half the cost of the latter.

At a recent meeting of the Academy of Sciences M. Jamin submitted a new electric burner, which he also recommended to chemists and physicists as a blowpipe. Two carbons are supported vertically abreast, hinged below, and drawn together at the top by a spring. A current is sent up one (A), down the other (B), then round a rectangular circuit inclosing the two, and passing first round A by current attraction the carbons are drawn apart, and the arc appears at the top and descends gradually, consuming one or both carbons. When the action of the rectangle is sufficient, the arc driven beyond the points is like a gas-flame, and M. Jamin receives it on a piece of lime, magnesium, or zirconium, getting intense light. It is also so hot as to fuse the lime. For the electric light this burner has considerable advantages—such as simplicity, since it requires no mechanism and requires no preliminary preparation beyond a support and the coke points; mechanical economy, since the number of flames is almost doubled; augmentation of light, since each of the new foci is almost twice as powerful as those of the old construction; quality of the light, which is whiter; more advantageous arrangement of the foci, which direct their greatest quantity of light downwards, where it is wanted, instead of up into the air, where it is useless; and, lastly, economy of combustible material.

M. Boudet de Paris has communicated to the Academy a paper "On the Electrical Inscription of Words." The transmitting apparatus is a very sensitive microphonic speaker, the carbons of which, instead of being pressed by a spring, are simply main-

tained in contact by the pressure of a small piece of paper folded in form of a V. The vibrations of the diaphragm of the receiving apparatus cannot be written, since the movements of the style, however delicate the apparatus, can scarcely be distinguished upon the lamp-black. To enlarge the magnetic vibrations of the receiver, the cover and the diaphragm of a Bell's telephone are taken away, and on the wood of the instrument there is fixed the end of a small, stiff, steel spring. The other end of the spring abuts on the surface of the magnetic nucleus, surrounded by its coil; to this extremity is soldered a small mass of soft iron weighing about 10 grms., and upon this mass, and in the produced line of the axis of the spring, is fixed a light style of bamboo, 10 centimetres in length, and terminating in a slender whalebone pen.

An improved siren with an electro-magnetic regulator is described by M. Bourbouze in the "Comptes Rendus." By means of this instrument sound can be made to pass from 8162 vibrations per second, through all the intermediary notes, to 128 vibrations.

The following resolution respecting the standard unit of Micrometry has been passed by the Royal Microscopical Society:—"That, in the opinion of this Society, the 1-100th of a millimetre is too large a unit for micrometric measurements, and that it is not expedient at present to prescribe by any formal resolution the adoption of a fixed standard for Micrometry."

The oil immersion objective has been made successfully by Messrs. Powell and Lealand.

Herr Zeiss proposes the following fluids as substitutes for oil of cedar wood for use with oil immersion objectives:—

1. Chloride of cadmium in glycerin ($CdCl_2$), 1·504.
2. Copaiva balsam oil, 1·504.
3. Chloride of zinc in water ($ZnCl_2$), 1·504.
4. Sulpho-carbolate of zinc in glycerin, 1·501.

Prof. Abbe considers the chloride of cadmium in glycerin very good optically, but somewhat too thick for convenient use. The oil of copaiva balsam is in every respect equal to oil of cedar wood, but not quite so fluid, and therefore better adapted to objectives of such large working distance as the $\frac{1}{8}$th. Chloride of zinc is not suited to prolonged observations, as after a few minutes' use it deposits small crystals on the slide and front lens: great care is required in the use of this and other aqueous fluids, lest the brass setting of the objective should be corroded. Platinum has been suggested as a material for mounting the front lens, but Herr Zeiss has found that its want of rigidity is fatal to its employment, as it will not stand when turned to the mere shell required.

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